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The Faculty of Business, Economics and Informatics of the University of Zurich hereby authorizes the printing of this dissertation, without indicating an opinion of the views expressed in the work.

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Framework paper

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This dissertation consists of three papers, two on current issues in transportation economics, the third analysing team production using sports data. What links the three papers is their empirical nature. Taken together, they do not form a unit within the same research field. The primary reason for this will become apparent below. In the following, I briefly outline the broader context, main research questions, methods used, results, and contributions of each of the three papers.

The two papers on current issues in transportation economics emerged from my employment at the Institute of Tourism and Mobility at the Lucerne University of Applied Sciences and Arts. Both papers add to discussions on the governance of public transport that are currently taking place in the industry and the associated research community.[1] Originally, these discussions arose after the second post-war period as the start of a lasting trend towards the liberalisation and deregulation of public service provision (Zatti, 2012). This trend is particularly evident in public transport, where competition *for* the market (competitive tendering) has become common practice in many countries. Ever since, politicians, the authorities, and researchers all around the world have tried to establish optimal regimes to regulate and govern public transport. In respect of subsidised public transport, the initial euphoria about the use of competitive tendering has abated in recent years, despite some success stories (Veeneman & Smith, 2016). Practitioners and researchers are increasingly stressing the role of transaction costs and discussing the design of hybrid or mixed forms of governance. The main idea is to combine competitive and cooperative governance forms to exploit their advantages and avoid their disadvantages (Merkert et al., 2018; Preston & Walters, 2020). Both of my papers on transportation economics fit into these ongoing debates.[2]

[1] For many years, the *Thredbo International Conference Series on Competition and Ownership in Land Passenger Transport* has constituted a premier international forum dedicated to advancing the field of public transport governance. I presented both my papers on transportation economics at this conference.

[2] Recently, Switzerland's public transport has experienced several scandals related to excessive subsidies (e.g., the largest public bus operator Postbus hiding illegal profits, Ernst & Young, 2018). As a result, public transport governance has increasingly attracted public attention, and the authorities have taken appropriate measures (Federal Office of Transport FOT, 2020b).

The first paper, *The impact of alternative governance forms of regional public rail transport on transaction costs. Case evidence for Germany and Switzerland* (Appendix A. 1, pp. 11–42),[3] identifies the dimensions and drivers of transaction costs in the governance of regional public rail transport. We compare two common but distinct governance forms. On the one hand, the cooperative governance form, as in Switzerland, is characterized by the absence of competitive elements. Incumbent transport operating companies (TOCs) provide public rail services on behalf of public transport authorities (PTAs) on the basis of directly awarded contracts. On the other hand, in the competitive governance form, as in Germany, competition for the market (competitive tendering) is the principal feature.

In studies about governance forms in public transport, transaction costs have often been mentioned as (potentially) substantial. It is therefore necessary to consider these costs when assessing different governance forms. However, an exhaustive and comprehensive examination of the dimensions and drivers of transaction costs in the governance of public transport is still missing. The central research question is therefore as follows: What dimensions and drivers of transaction costs emerge with different forms of public transport governance?

Following the explorative nature of our research question, we apply qualitative methods based on grounded theory (Glaser & Strauss, 1967). More particularly, we use a multiple case study approach drawing on the contrasting cases of Switzerland's and Germany's respective forms of governance for regional public rail transport. We gather data from semi-structured interviews with industry representatives (TOCs, PTAs, consultants, and researchers). Interview transcripts and additional documents are analysed in multiple stages using qualitative content analysis.

The main results are as follows. Besides the procedure for awarding contracts, transaction costs accrue in the provision of customer-friendly system services (e.g., timetable integration) and when establishing the institutional framework (also referred to as institutional transition costs). In addition, there is a dynamic dimension to the transaction costs, on which learning effects, emerging challenges, and efforts to advance public transport potentially have a strong influence. Overall, neither form of governance seems to be superior to the other in terms of the level of transaction costs. However, there are substantial differences in where and why such costs occur. In the cooperative governance form, the major driver of transaction costs is the necessity for PTAs to develop and implement various instruments, so-called competition sur-

[3] A version of this paper has been published in *Research in Transportation Economics.*

rogates, to overcome information asymmetries regarding cost efficiency. Examples of such instruments are micromanagement of negotiations and contracts, tight monitoring of the TOCs' costs, and benchmarking. Transaction costs tend to be reduced if there is a high level of trust among stakeholders. In the competitive governance form, on the other hand, transaction costs are mainly driven by the PTAs' role as market makers. PTAs have to ensure that the market is attractive to potential bidders. This requires, e.g., the design of fair and efficient tendering procedures and limiting the TOCs' risks (especially the risks related to revenue and investment in rolling stock). Formalisation and a clear allocation of responsibilities limit transaction costs. Ultimately, institutional transition costs are relevant, as when, e.g., a shift occurs from cooperative to more competitive governance forms.

Our results contribute to the ongoing debate on the effective and efficient design of governance for public rail transport. Our in-depth analysis of the dimensions and drivers of transaction costs helps authorities and politicians to develop existing governance forms further to increase the overall welfare effects of public transport. As a promising topic for future research, we identify a need for a thorough quantitative analysis of transaction costs in terms of dimensions and drivers. So far, quantitative results remain anecdotal. Future research could also include more case studies, especially of cooperative governance forms with long contract durations, as well as hybrid governance forms.

The second paper, *Is the mere threat enough? An empirical analysis about competitive tendering as a threat and cost efficiency in public bus transportation* (Appendix A. 2, pp. 43–65),[4] examines how competition for the market indirectly affects cost efficiency of regional public bus services in Switzerland. An indirect effect may arise because PTAs can choose between competitive tendering or directly awarded public transport contracts. In the latter case, competitive tendering can be used as a threat to bus operating companies (BOCs), as well as being a basis for benchmarking. Indirect effects therefore appear in at least three circumstances. First, PTAs establish a credible threat by partially using competitive tendering in their area of responsibility. Second, BOCs exposed to competitive tendering reduce cost inefficiencies in services operated under non-tendered contracts as well. Third, PTAs use sophisticated benchmarking based on revealed costs from competitively tendered contracts. Previous studies of the impact of governance instruments on cost efficiency exclusively focus on the direct effects of competitive tendering; no study so far has examined the potential indirect effects.

[4] A version of this paper has been published in *Research in Transportation Economics*.

I use panel data on the costs of all regional public bus lines in Switzerland. Based on a Cobb-Douglas cost function, I estimate a stochastic frontier model. Different operationalisations of the indirect effects of competitive tendering serve as explanatory variables for cost inefficiency.

The results show two main indirect effects. First, BOCs with experience of competitive tendering generally operate significantly closer to the cost efficiency frontier than BOCs without such experience. Second, cost efficiency scores increase when PTAs introduce sophisticated (model-based) benchmarking. The fact that a PTA starts using competitive tendering has a significant positive effect on cost efficiency of non-tendered contracts in most but not all models. One explanation for the latter result is that the threat to use competitive tendering may not be credible in all instances.

By finding evidence for indirect effects of competitive tendering, the paper contributes to the ongoing debate on effective and efficient governance forms for regional public transport. Exploiting the indirect effects of competitive tendering could be a major feature of a hybrid governance form. It would allow PTAs to push BOCs closer to the cost efficiency frontier while not mechanically applying competitive tendering. This leaves room for exploiting the advantages of cooperative instruments.[5]

The preliminary insights of the second paper should be complemented with similar studies on this issue, e.g., in a different regulatory context. In addition, future research could focus on various aspects of a hybrid governance form. One example is the optimal design of combining cooperative and competitive governance instruments. Another, broader research question complements the focus on cost efficiency by assessing how different governance forms affect innovation, customer orientation, and, ultimately, passenger numbers.

I now turn to the third paper, where we study team production using data from professional team sports. Empirically examining research questions in economics by exploiting the abundance of professional sports data fits well with the research interests at Professor Dietl's chair. Accordingly, Prof. Dietl and Dr. Orlowski are co-authoring this paper with myself. Professional sports have often been used as a real world laboratory in economic research. In particular, sport settings occasionally allow quasi-experiments to identify causal effects (Kahn, 2000), as sports contests take place in rather controlled environments and under well-defined sets of standardised rules (Rosen & Sanderson, 2001). Inputs, outputs, and outcomes can be clearly identified

[5] In Switzerland, the current regulatory reform is going in that direction. However, no substantial increase in the use of competitive tendering is planned (FOT, 2020a).

and measured. Nowadays, data on, e.g., individual performance during sports contests is abundant, detailed, and of high quality. Professional sport therefore provides a promising setting for examining research questions beyond the sports context alone. One example is the economics of team production.

In the third paper, *The importance of high performing team members in complex team work. Results from quasi-experiments in professional team sports* (Appendix A. 3, pp. 67–88), we study peer effects of high performing team members in complex team production. Previous studies of peer effects in teams usually examine sequential tasks or settings with few interactions among team members. Instead, we focus on reciprocally interdependent team production, which is prevalent in many industries (e.g., R&D, software development, professional sports, engineering). Reciprocal interdependence means close, constant, often ad-hoc interaction among multiple team members. We empirically examine the effects of high performing team members on other team members' individual performance in terms of efficiency, output, risk taking, and task allocation.

For this purpose, we use play-by-play data from professional basketball games in the National Basketball Association (NBA). To identify peer effects, we exploit unexpected injury dropouts of high performing players during a game. This quasi-experimental setting allows us to use a difference-in-difference estimation approach. We compare the change in players' individual performance over time within a game using two groups. In the first group (treatment group), a high performing player drops out due to an injury. In the second group (control group), no high performing player drops out.

We find that, after an injury dropout of a high performing player, the other players of the team continue to fulfil their tasks as efficiently as before. However, they increase risk, reduce output, and divide tasks more evenly among themselves. These effects occur primarily when the high performing player has an integrative, team-oriented role within the team (compared to a rather self-oriented role). In addition, we observe that the subgroup of other high performing players, who do not drop out, try to compensate for the absent high performing player by increasing their output. They could be interpreted as trying to step out of the shadow of their high performing peer.

The empirical analysis of peer effects (especially of high performing team members) in reciprocally interdependent team production has received little attention in the literature so far. We fill this gap by showing that in such contexts high performing team members alter other team members' individual performance in various ways. We argue that, although behavioural concepts may play a certain role in explaining these results, the facilitating nature of high performing team members is the central mechanism behind the observed peer effects.

Future research could deepen understanding of the importance of high performing team members. The insights of the third paper might be extended by studying how other team members' effort levels and routines of interaction depend on high performing team members. Another related research question is the role and importance of high performing team members in critical situations. The professional sports setting again offers a promising opportunity to study these research questions.

References

Ernst & Young. (2018). *PostAuto Schweiz AG. Auswertungen zu Periode 15-Umbuchungen für den Zeitraum 2007-2015*. https://www.post.ch/de/ueber-uns/aktuell/postauto-untersuchung

Federal Office of Transport FOT. (2020a, May 12). *Bundesrat will Bestellsystem im öffentlichen Regionalverkehr optimieren* [Press release]. https://www.bav.admin.ch/bav/de/home/publikationen/medienmitteilungen.msg-id-79421.html

Federal Office of Transport FOT. (2020b). Neue Regeln gegen Subventionsmissbrauch. *BAV-News November.* https://www.bav.admin.ch/bav/de/home/publikationen/bav-news/ausgaben-2020/bav-news-november-2020/3.html

Glaser, B. G., & Strauss, A. (1967). *The discovery of grounded theory: strategies for qualitative research.* New York: Aldine.

Kahn, L. M. (2000). The Sports Business as a Labor Market Laboratory. *Journal of Economic Perspectives, 14*(3), 75–94.

Merkert, R., Preston, J., Melkersson, M., & Link, H. (2018). Workshop 2 report: Competitive tendering and other forms of contracting-out: Institutional design and performance measurement. *Research in Transportation Economics, 69*, 86–96.

Preston, J., & Walters, J. (2020). Workshop 1 report: Models of mainstream public transport provision. *Research in Transportation Economics, 83.*

Rosen, S., & Sanderson, A. (2001). Labour Markets in Professional Sports. *The Economic Journal, 111*(469), 47–68.

Veeneman, W., & Smith, A. S. J. (2016). Workshop 2 report: Effective institutional design, regulatory frameworks and contract strategies. *Research in Transportation Economics, 59*, 60–64.

Appendix: papers included in this dissertation

A. 1

The impact of alternative governance forms of regional public rail transport on transaction costs. Case evidence from Germany and Switzerland†

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Keywords: subsidised public transport, transaction costs, governance form, principal-agent problem, competitive tendering, direct awarding, negotiations
JEL classification: D44, K23, L14, R40, L92

Abstract

This article addresses the transaction costs of different governance forms in regional public rail transport by comparing Germany's competitive contract awarding model with Switzerland's direct contract awarding model. Using a multiple case study approach with contrasting cases, we propose a concept of transaction costs with four dimensions: the awarding procedure, the institutional framework, the provision of system services, and the impact of learning and innovation. We then identify drivers of transaction costs in both governance forms. In Germany's competitive governance form, public transport authorities (PTAs) must ensure effective competition using different instruments, and transaction costs are reduced by means of a clear definition and allocation of responsibilities. In Switzerland's cooperative governance form, costly competition surrogates serve to overcome information asymmetries, while an informal and trusting culture of cooperation prevents high transaction costs. Factors such as the complexity of different kinds or unforeseen behaviour by PTAs increase transaction costs with either governance form. Our results suggest that transaction costs are not a legitimate argument against competition for the market. However, introducing it in Switzerland's regional public rail transport would trigger high institutional transition costs and necessitate a change in culture.

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1. Introduction

In most European countries, regional public transport (RPT) authorities mandate transport operating companies (TOCs) as contracting partners to provide RPT services.[1] Two distinctive ideal types of governance apply: the competitive tendering model, i.e., competition *for* the market, and the cooperative model involving the direct awarding of contracts. Today, efficient use of the large volumes of public funds devoted to RPT is a major policy concern, especially given the substantial increase in the demand for RPT that is expected in many places. Therefore, optimal governance of RPT in terms of cost efficiency, quality, customer orientation, and innovation on the one hand and transaction costs on the other hand are of major interest.

The primary focus of our study is on transaction costs. Although the choice of optimal RPT governance forms has been discussed in the literature, van de Velde and Beck (2010), Wallis et al. (2010), and others state that more knowledge of transaction costs is needed to be able to compare the costs and benefits. In the political debate, transaction costs are occasionally put forward as an argument against competitive tendering (Hanstein, 2014; SBB, 2014). We believe that a better understanding of transaction costs may support improvements to and advances in RPT governance. However, to the best of our knowledge, no detailed and comprehensive study of the transaction costs of different RPT governance forms exists to this day. We therefore seek to shed light on the following research questions: *What types or dimensions of transaction costs emerge within the two governance forms—competitive vs. cooperative—for PTAs, TOCs, and possibly other stakeholders? Which transaction costs depend on the governance form, and which transaction costs are attributed to other factors? What are the relevant drivers of these transaction costs? Finally, how high are these transaction costs likely to be?*

By answering these research questions, our paper contributes to the ongoing debate in both academia and practice on optimal governance forms in RPT. We analyse our research questions using a comparative case study approach exploring multiple contrasting cases from Germany (the competitive governance form) and Switzerland (the cooperative governance form). We do not find evidence that the level of transaction costs of one governance form is substantially higher than in the case of the other. What differs is where and why transaction costs occur, which relates directly to the institutions, actors, practices, and levels of trust among stakeholders associated with the respective governance form. With regard to the particular drivers of

[1] According to legal definitions in both Germany and Switzerland, RPT is passenger transportation within a region with average distances of no longer than 50 kilometres or travel time no longer than one hour. Although we use the term RPT, we only consider *railway* transport and leave aside *bus* transport (unless explicitly stated).

transaction costs, the main difference between the two governance forms is the way PTAs ensure that TOCs produce satisfactory RPT services in terms of cost efficiency, service levels, and quality.

The remainder of the paper is organised as follows: The next section summarises the relevant literature. Section 3 presents the empirical context, namely, the cases we are analysing. In section 4, we describe the qualitative research design. Results are provided in section 5, followed by a discussion and conclusion to the paper in section 6.

2. Literature review

The existing body of literature on awarding mechanisms, transaction costs, and public transport governance provides a valuable basis for an in-depth analysis of transaction costs in RPT governance. This section provides a summary of the relevant literature.

2.1 Competitive tendering vs. direct awarding in public transport

PTAs use *competitive tendering* to enhance cost efficiency, given a certain level of output and service quality (Augustin & Walter, 2010; Lalive & Schmutzler, 2011). A *sine qua non* for achieving this is a functioning bidding market to keep the market contestable (Kain, 2006; Koller, 2012; Laffont & Tirole, 1993): entry barriers need to be low (Beck, 2011a), and tendering has to take place regularly (Hensher & Wallis, 2005). Important barriers to entry include revenue risks, complexity, high transaction costs, and the incumbent's competitive advantages (Augustin and Walter, 2010; Beck, 2011; Boitani and Cambini, 2006; Gross, 2009).[2] There is, however, a trade-off between low entry barriers and economies of scale, scope, and density (Augustin & Walter, 2010). Moreover, to provide system services, PTAs must find a solution to overcome the free-rider problem of competitive environments (Gross, 2009; Kern, 2014). In other words, there is a trade-off between the efficiency of subsystems (through competition) and the efficiency of the entire system (through integration) (Finger et al., 2012). Transaction costs are occasionally mentioned as a disadvantage of competitive tendering, primarily in first-round tenders (Bajari et al., 2008; Lalive & Schmutzler, 2011; Wallis et al., 2010). Laffont and Tirole (1993: 307) summarise generally: "Organizing auctions … is costly. Procurers incur the

[2] The incumbent may have specific knowledge about, e.g., revenues, which gives it a considerable advantage in the bidding procedure if no specific regulation applies (such as the obligation to share data on revenues). This potential caveat of competition for the market relates to Williamson's "fundamental transformation" (Williamson, 1985: 61). Even if there is lively competition at the bidding stage, the subsequent contractual relationship will be bilateral. This (temporal) monopoly position gives the incumbent a potential competitive advantage for future competitive tenders.

'processing cost' of writing requests for proposals and reading the proposals, making sure that the language and terms of the proposals are unambiguous. Potential suppliers also spend substantial amounts of time preparing contracts … . To this must be added the lengthy assessment of subjective attributes of bids … . Certainly, such transaction costs exist with a single potential supplier, but they tend to grow with the number of bidders". Another source of transaction costs are unforeseen ex-post negotiations (Hensher & Stanley, 2008; Mees, 2007), service disruptions, or the bankruptcy of TOCs (Alexandersson & Hultén, 2006).

Compared to competitive tendering, *direct awarding* with negotiations is more flexible and eases the problem of dealing with high levels of complexity. Long-term collaboration between PTA and TOC enables professional cooperation and fosters mutual trust. On the other hand, mutual trust is a premise of exploiting the advantages of negotiations (Bajari et al., 2008; Hensher & Stanley, 2008). Mutual trust can substitute for detailed contracts and costly lawsuits in cases of conflict, thus reducing transaction costs (Hensher & Stanley, 2010; Merkert & Hensher, 2013; Parker & Hartley, 2003). To achieve cost efficiency with direct awarding, however, it is important to use incentive contracts, since information asymmetry and incumbent bargaining power still exist (Bajari et al., 2008; Lalive & Schmutzler, 2011). In addition, if awarding occurs regularly, TOCs have barely any incentive to decrease costs because profits are skimmed, and losses result in higher levels of compensation (Finger & Holterman, 2013). Incentive contracts may be more suitable than competitive tendering in achieving soft goals, such as service quality, and they may have lower transaction costs (Bajari et al., 2008; Hensher & Wallis, 2005). Direct awarding, conversely, can increase transaction costs, e.g., if complex and data intensive incentive schemes are used and when negotiations become lengthy (Hensher & Wallis, 2005; Koller, 2012).

Empirical studies of awarding procedures in public transport often focus on the impacts of competitive tendering on cost efficiency, service levels, and service quality (Beck et al., 2007; Hensher & Wallis, 2005; Koller, 2012; Lalive & Schmutzler, 2008, 2011; Pollitt & Smith, 2002). There is a consensus that competitive tendering usually reduces compensation per train-kilometre and leads to increased service levels and higher quality. For Germany's RPT, Lalive & Schmutzler (2011) and mofair & Netzwerk Privatbahnen (2009) quantify the savings in compensation payments per train-kilometre at 26 percent. Some studies, in contrast, reveal cost increases, although it is difficult to elicit the reasons for this (Boitani & Cambini, 2006; Hensher et al., 2007; Kain, 2006; Nash & Wolański, 2010). Others report lower unit costs after first-round tenders, but rising costs in follow-up tenders (Hensher & Stanley, 2008; Hensher & Wallis, 2005). Wallis et al. (2010) conclude from a study of bus services in Adelaide, Australia, that direct awarding with negotiations and incentive contracts is preferred to re-tendering when the incumbent is already operating efficiently. In this case, re-tendering does not increase efficiency but still increases transaction costs.

In summary, the literature on the governance of public transport provides valuable insights into how different governance forms and contractual designs work in practice. The studies usually analyse outcomes such as cost efficiency. They occasionally mention transaction costs, but do not consider them systematically or comprehensively.

2.1 Transaction cost economics and principal-agent theory

Transaction Cost Economics, an important theme in *New Institutional Economics*, focuses on the alignment of transactions to governance forms. Central to the analysis are ex-post risks in contractual relationships, such as bilateral dependencies, unknown quality, and opportunism. Transaction costs are compared with efficiency of production in choosing an appropriate governance form (Coase, 1937, 1960; Williamson, 1996). Usually, three characteristics of transactions determine the level of transaction: uncertainty, frequency, and asset specificity, the last being rated the most important. Governance forms are optimally chosen depending on the peculiarity of these characteristics, as well as on the institutional, social, and technological environment (Mizutani & Uranishi, 2012; van de Velde et al., 2006; Williamson, 1996, 2000).

The literature provides different definitions of transaction costs (e.g., Arrow, 1969; Coase, 1937; Dietl, 2007; Merkert, 2010; Williamson, 1996), which are sometimes separated from institutional transition costs, i.e., the costs of institutional change. Institutional transition costs are a form of dynamic transaction costs that may also include efforts by political decision-makers to overcome resistance to this institutional change (Garrick et al., 2013; Marshall, 2013).

It has often been argued that modern information and communication technology (ICT) minimises the importance of transaction costs. Automative innovations, e.g., may "lead to an overall shift toward proportionally more market coordination" (Malone et al., 1987: 484). Applied to the present context, ICT may reduce costs in governing public transport and thereby facilitate market-oriented reforms such as privatisation (Preston, 2002). However, intensified use of ICT can increase complexity and may require different forms of coordination, thereby increasing transaction costs (Cordella, 2006; Den Butter, 2012).

Principal-agent theory is another useful approach for analysing PTA-TOC relationships, a classic case of the principal-agent problem. Principal-agent theory primarily relates to the alignment of the principal's and agent's respective incentives under information asymmetry. As principals, PTAs try to overcome information asymmetry with the agent (the TOCs) by deploying instruments such as incentive contracts or tight monitoring. In addition to the costs of applying these instruments, there is usually a welfare loss (residual loss) because of the remaining information asymmetry. Both costs are referred to as agency costs (Picot, 1991).

Although transaction costs in PTA-TOC relationships have recently attracted some attention, they have rarely been addressed empirically. In general, increased cost efficiency after a competitive tender indicates a favourable cost-benefit ratio from the TOCs' point of view. For British rail franchises, Merkert (2010) observes a reduction in TOCs' transaction costs over time that is achieved through learning effects and mutual trust between stakeholders. Nash and Wolański (2010) report high transaction costs for competitive tendering in the UK, which, however, are offset by cost efficiency gains. Both studies only incorporate the internal costs of TOCs and thus neglect consulting costs and PTAs' costs. In the study of bus services in Adelaide mentioned above, Wallis et al. (2010) find significantly higher transaction costs for competitive tendering than for direct awarding with negotiations. Beck et al. (2007) analyse two competitively tendered rail services in Germany and state that transaction costs only represent a small fraction of production cost savings. These two studies break down transaction costs into different categories and allocate them to different stakeholders. However, they do not analyse the underlying drivers of transaction costs in further detail. Resch and Neth (2006) report much higher transaction costs for German railway TOCs with competitive tendering than with direct awarding. The authors explain this result with reference to the need to build new institutions and to reallocate the responsibilities for system services to PTAs. Thus, they use a definition of transaction costs that goes beyond the mere costs of contract awarding and includes, e.g., institutional transition costs. Their study, however, focuses on transaction cost of competitive tendering and neglects those of direct awarding by assumption. Finally, some studies explicitly mention particular drivers of transaction costs. Kain (2006) reports that high transaction costs in the UK and Australia occur in renegotiations after the original bids in competitive tenders have proved too optimistic. Merkert and Hensher (2013) find transaction costs to be higher in Australian bus RPT than in regional air transport because of the stronger trusting relationships and clear but simple contracts in the latter case.

In summary, despite the increased awareness of transaction costs in governing public transport, no study covers them in a comprehensive way. Nevertheless, the existing studies already provide valuable information about the categories and drivers of transaction costs.

3. Empirical context

3.1 Germany

Germany's railway reform of 1994 was a reaction to the shrinking importance of RPT since the 1950s and to the poor performance and high financial risks to public budgets posed by the then state monopolists, the *Deutsche Bundesbahn* and *Deutsche Reichsbahn* (Schwilling et al., 2014). Under the reform, responsibilities were reallocated, and funding was reorganised. The ordering principle, the compensation principle, and competitive tendering were introduced.[3] In addition, the federal states were given more responsibilities and more discretion (Aderle, 2013; Monopolkommission, 2011). Even though legal certainty about the mandatory use of competitive tendering in RPT has only recently been achieved,[4] several PTAs began to award contracts competitively right after the reform. Besides the usual competitive tendering procedure, under certain circumstances PTAs can apply the so-called competitive negotiation procedure, which includes negotiations with bidders (Achenbach et al., 2013).[5] Competition for the market in Germany's RPT is usually restricted to service provision and the procurement and maintenance of rolling stock. Other functions on the tactical and strategic level are provided by PTAs, such as the integration of services in timetables and fares, or have remained with the incumbent holding company, the *Deutsche Bahn (DB)*, such as infrastructure management and provision of real-time customer information.[6]

Germany is widely recognised as an example of good practice regarding public transport liberalisation and competition in RPT (Kummer et al., 2013). After the railway reform (and with ongoing experience), service levels, cost efficiency, and service quality have risen impressively (Aderle, 2013; Schwilling & Bunge, 2014). The incumbent *DB Regio* is still the market leader, although competitors' market share rose to 27.4 percent of total train-kilometres in 2014 (mofair & Netzwerk Privatbahnen, 2014). Table 1 provides a brief summary of our German

[3] PTAs define the public transport services they want to procure from a TOC (ordering principle). The PTA and TOC agree in a contract on these services and on compensation for the expected residual costs the TOC cannot recover from revenues (compensation principle) (Desmaris, 2014).

[4] Decision X ZB 4/10 of the Federal Court of Justice, 2011.

[5] PTAs use competitive negotiation procedures when the service being provided is complex or has novel challenges, such as awarding an entire suburban railway network. In such instances, it is often not possible (or is subject to considerable risk) to describe the required service definitively at the outset. Competitive negotiation procedures can also be used when no suitable bids were submitted initially (e.g., with respect to the maximum possible compensation payment). PTAs and bidders then can discuss open questions about service and contract specifications, thus contributing jointly to outcome optimisation, avoiding costly written question and answer games, and reducing the risk of legal consequences.

[6] The different levels of planning, control, and decision-making in the provision of public transport services are conceptualised in the STO (Strategic–Tactical–Operational) framework (van de Velde, 1999b).

case studies. All three represent state of the art competitive tenders, and in all cases the PTAs used a competitive negotiation procedure.

Table 1 Description of German cases.

Case	Main features	Interviewees
S-Bahn Rhein-Main	▪ Suburban railway network in metropolitan area ▪ Three lots; nine lines; about 15 million train-kilometres per year—fourth largest suburban railway network in Germany ▪ Highly experienced and professional PTA ▪ First-round tender ▪ Gross contract; comprehensive incentive contract ▪ Contract duration: 15–22 years	▪ PTA (Rhein-Main-Verkehrsverbund RMV) ▪ Incumbent TOC (DB Regio) ▪ Unsuccessful bidder (Cantus)
S-Bahn Rhein-Ruhr	▪ Part of suburban railway network in metropolitan area ▪ Two lines; about 3.6 million train-kilometres per year—part of the third largest suburban railway network in Germany ▪ Highly experienced and professional PTA ▪ First-round tender ▪ Gross contract; comprehensive incentive contract ▪ Contract duration: 15–16 years	▪ PTA (Verkehrsverbund Rhein-Ruhr VRR) ▪ Incumbent TOC (DB Regio)
Dieselnetz Südwest	▪ Large rural RPT network ▪ Two lots; 16 lines; about 10 million train-kilometres per year ▪ Several PTAs involved ▪ First-round tender ▪ Operator change; partially net contract; quality incentive contract ▪ Contract duration: 22.5 years	▪ Lead PTA (Zweckverband Schienenpersonennahverkehr Rheinland-Pfalz Süd ZVSPNV Süd) ▪ Incumbent TOC (DB Regio)

3.2 Switzerland

Switzerland reformed its RPT in the wake of liberalisation in the European Union (EU) (Desmaris, 2014). The ordering principle and compensation principle were introduced. Cantonal PTAs and the Federal Office of Transport (FOT) order and fund RPT services jointly, funding being shared equally (shared ordering). Cantonal PTAs take the lead in the awarding procedure but are supported by the FOT, which is also responsible for nationwide coordination, standardisation, and benchmarking.[7] Contract duration is two years. PTAs negotiate exclusively with the incumbents, which are owned by the state and hold transport licences for their services for as long as 25 years (Finger et al., 2012). As an extension to the two-year ordinary transport contracts, PTAs and TOCs can negotiate target agreement contracts with stipulations regarding cost efficiency and quality goals for longer periods. Competitive tendering is a voluntary option,

[7] Benchmarking of cost, revenue, and service level KPIs is used to support the evaluation of TOCs' offers. There is, however, no benchmarking in terms of yardstick competition nationally. It is only recently that some cantonal PTAs have started to develop a model-based benchmarking approach (see Shleifer, 1985, for a formal theory of yardstick competition, and Dalen & Gómez-Lobo, 2003, for an application in public transport).

but it has never yet been used for public rail transport.[8] When new RPT services are introduced, however, PTAs sometimes invite preselected TOCs to submit a bid, thereby creating a degree of competition for the market.

In general, Swiss RPT is characterised by a particularly high level of system integration, with frequent services, synchronised timetables, integrated connections, comprehensive fare integration, and high levels of punctuality (Finger et al., 2012). The *Schweizerische Bundesbahnen (SBB)* is the largest incumbent and has extensive responsibilities for system services such as timetable-scheduling, supply-planning, and real-time customer information. Even in the absence of competitive instruments, reforms are deemed to have led to increased cost efficiency, higher service levels, and better service quality (Desmaris, 2014; Ecoplan, 2014). Swiss taxpayers heavily subsidise RPT in absolute terms.[9] Financial sustainability therefore poses a big challenge for the future (Desmaris, 2014; Meister, 2012). Table 2 briefly summarises the Swiss cases.

Table 2 Description of Swiss cases.

Case	Main features	Interviewees
Regio S-Bahn Basel (SBB's part)	▪ Rather small suburban railway network ▪ Five lines; about 4 million train-kilometres per year; extending to Germany and France ▪ Several PTAs involved ▪ Net contract; 'small' quality incentive contract	▪ Lead PTA (Kanton Baselland BL) ▪ National PTA (FOT) ▪ Incumbent TOC (SBB)
S-Bahn Zurich (SBB's part)	▪ Largest, most complex railway network in Switzerland ▪ 14 lines; about 19 million train-kilometres per year ▪ Lead PTA is the most professional PTA in Switzerland; several PTAs involved ▪ Net contract; comprehensive incentive contract (target agreement contract)	▪ Lead PTA (Zürcher Verkehrsverbund ZVV) ▪ National PTA (FOT) ▪ Incumbent TOC (SBB)

[8] There was one restricted competitive tendering call in the 1990s with two preselected bidders, resulting in the so-called *Seelinie* being transferred from the incumbent *Schweizerische Bundesbahnen (SBB)* to the entrant *Mittelthurgaubahn (MThB)*. Because the legal framework at that time did not include competitive tendering as an awarding mechanism, this procedure was justified as an informal experiment (van de Velde, 1999a).

[9] In 2012, PTAs' compensation for RPT was more than CHF 1.8 bn (Federal Department of the Environment, Transport, Energy and Communications DETEC, 2016), amounting to around USD 1.9 bn and EUR 1.5 bn using average exchange rates for 2012 (Swiss National Bank, 2016). Approximately two-thirds go into rail RPT and one-third into bus RPT. If more money is required, stakeholders usually find a compromise to cover the gap (soft budget constraint). In contrast, public compensation for the operation of rail RPT in Germany amounted to EUR 5.75 bn in 2012 (Verband Deutscher Verkehrsunternehmen VDV, 2013).

4. Methodology

Because of the pronounced exploratory nature of our research questions, we follow a qualitative research design.[10] Our empirical research method is based on grounded theory (Glaser & Strauss, 1967; Strauss & Corbin, 1998). We apply a multiple case study approach with contrasting cases to reveal the similarities and differences between the two governance forms (Baxter & Jack, 2008; Yin, 2014). Cases are selected according to theoretical sampling using different criteria derived from the literature on public transport governance and from initial discussions and interviews with industry representatives and experts (Table A 1 in the Appendix). The intention is to cover a wide range of up-to-date institutional settings, practices, and challenges in respect of both governance forms. Ultimately, the goal is to achieve qualitative representativeness that allows analytical generalisations (Yin, 2014). We consider German and Swiss RPT to be sufficiently similar and, at the same time, as sufficiently different to be compared with each other, as well as to ensure mutual learning (Beck et al., 2007; Gross, 2013; Kummer et al., 2013).[11]

Based on an extensive literature review and on the discussions and expert interviews mentioned above, we develop a conceptual frame of reference for collecting and analysing the data. The frame of reference consists of a matrix with different dimensions of transaction costs and corresponding working hypotheses on how institutions, actors and their practices, and contexts affect transaction costs. We collect data in semi-structured guided interviews using interview guides we develop based on the frame of reference.[12] Despite the use of interview guides, interviewees are completely free in how they answer the questions, which gives the interviews a narrative character. We complement the interviews with document analysis (e.g., of tendering documents). If new insights emerge from the case study interviews, we adapt the frame of reference and the interview guides accordingly (Flick, 2012). We stop gathering data when interviews no longer reveal any new information (Glaser & Strauss, 1967).

Following the procedure proposed by Strauss and Corbin (1998), we then apply qualitative content analysis with repeated coding of interview transcripts, thus gradually identifying the relevant dimensions and drivers of transaction costs. To check for the plausibility of our qualitative results, we also collect some quantitative data.[13] Finally, all the results are discussed with

[10] A more comprehensive description of the research design can be found in the Appendix to this paper.
[11] For a detailed overview of the two institutional frameworks (and others in Europe), see Finger et al. (2012).
[12] We conduct nine case study interviews with one to three interviewees of a duration of 60 to 180 minutes each (Table 1, Table 2, and Table A 1).
[13] Quantitative data on transaction costs in RPT is sparse and incomplete. At best, these data constitute anecdotal evidence and provide illustrations relating to the qualitative findings.

an expert panel consisting of industry representatives from Germany and Switzerland. Thereby, we aim to ensure intersubjectivity through communicative validation (Diekmann, 2007; Flick, 2012).

5. Results

5.1 Dimensions of transaction costs

We propose a comprehensive concept of transaction costs that includes the four dimensions presented below.

Contract awarding procedure. Here, all classical transaction costs (information costs, negotiation costs etc.) occur and are treated as static transaction costs, given the institutional framework.

Institutional framework. To be able to award contracts, a corresponding institutional framework has to be established and continuously adapted to a changing environment. By institutional framework, we broadly mean a reliable legal framework, qualified PTAs, and effective and efficient decision-making processes to ensure the functioning of awarding procedures. Establishing a suitable institutional framework entails a cost that Marshall (2013) refers to as institutional transition costs. Depending on their design and quality, formal institutions, as well as informal institutions like business culture, affect the level of transaction costs.

System services. From a customer's point of view, the integration of fares and timetables and timely and comprehensive customer information are crucial because they decrease generalised user costs (Gross, 2009; Preston, 2010). Such system services have to be provided either by one powerful and qualified stakeholder (e.g., the incumbent or a PTA), or through cooperation between different stakeholders. Accordingly, transaction costs and institutional transition costs establishing the corresponding institutional framework may differ. Moreover, if the responsible actors fail to provide adequate system services, customers experience welfare losses (Preston, 2010).

Dynamic perspective. We start from the assumption that transaction costs, ceteris paribus, decline over time due to learning effects. In a dynamic environment, however, the ability to adapt flexibly to new circumstances and opportunities is crucial in terms of "adaptive efficiency" (North, 1992: 9). Besides the potential decrease in transaction costs through learning effects, this fourth dimension therefore contains transaction costs related to adaptation, innovation, and the advancement of RPT.

Figure 1 summarises the four dimensions of transaction costs. Within a given institutional framework, transaction costs are incurred in awarding procedures and in the provision of customer-friendly system services. In the dynamic perspective, adaptation and learning influence transaction costs, both positively and negatively. If institutional change occurs, e.g., in the direction of a competitive governance form, institutional transition costs accrue. Subsequently, the new (or adapted) institutional framework affect the other dimensions of transaction costs.

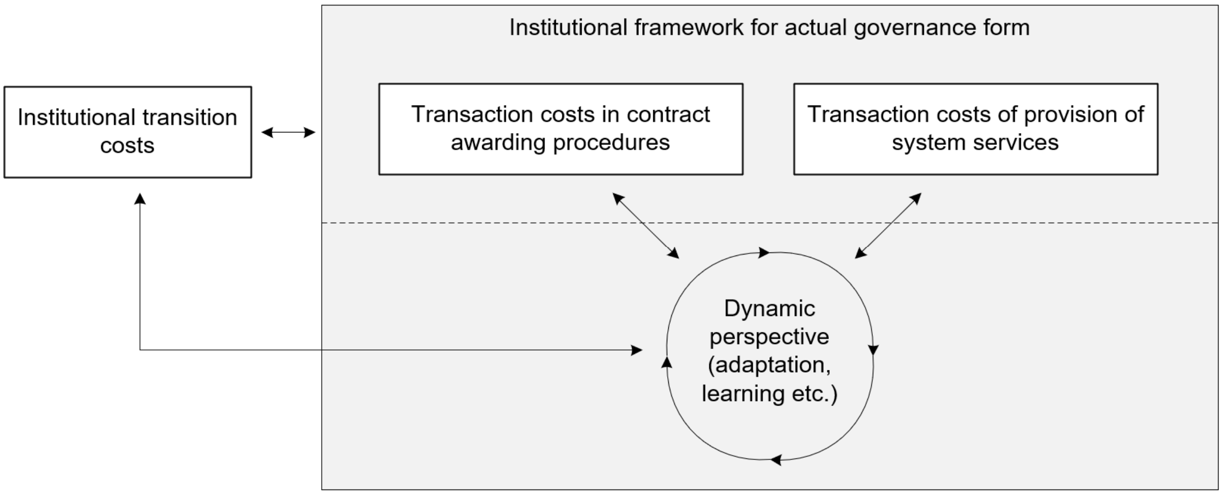

Figure 1 Four dimensions of transaction costs within RPT governance.

5.2 Drivers of transaction costs

Independent drivers of transaction cost

In public debates, some drivers of transaction costs are considered to be a direct consequence of competition, even though in principle they are independent of the governance form. In other words, these transaction costs appear in either governance form to a significant extent and for similar reasons. We identify four such drivers. The first three are potentially reinforced by the degree of formalisation of contractual relationships, which in our case studies is more prevalent the competitive governance form than in the cooperative governance form (see below).

The *number of stakeholders* drives transaction costs by increasing the need for coordination and the probability of conflicts over goals, budgets etc. This feature is more prevalent in Switzerland than in Germany due to shared ordering and the spatial structure of many small PTAs (political borders rarely coincide with the boundaries of RPT networks). If the number of stakeholders is low, fewer interfaces have to be managed.

Unforeseen changes and adjustments during awarding procedures or contract periods heavily increase transaction costs. Work has to be redone, signing the contract is delayed, stakeholders and potential bidders are discouraged, and planning reliability declines. An example from Switzerland demonstrates this in an obvious way: in 2014, a nationwide fare increase made it necessary to recalculate and renegotiate all current RPT contracts.

Technological, legal, and operational *complexity* affects transaction costs, a result well known from Transaction Cost Economics. It is more difficult to deal with complexity in long-term contracts (see below). For Germany's PTAs, one way to cope with complexity is to use competitive negotiation procedures. In contrast, short contract periods in Switzerland's RPT ease the handling of complexity. The same is true of more flexible contracts elements, such as regular meetings between the parties and liberal adjustment clauses.

Learning effects result from repetition, experience, standardisation, and sample documents. Learning effects allow PTAs to deal with higher levels of complexity. A common strategy in the competitive governance form is to start competitive tendering with isolated lines in peripheral areas and then move on to networks that are more complex. In addition, legal certainty, institutional stability, and extensive use of ICT (e.g., electronic tendering documents) lower transaction costs. However, new internal and external challenges appear that may substantially increase transaction costs. Examples are data requirements for electronic controlling and monitoring or the global financial crisis of 2008, which held up the funding of new rolling stock by TOCs. In the latter example, the governance form clearly matters, as the results in the next section demonstrate.

Transaction cost drivers directly related to the governance form

We identify five drivers of transaction costs that directly depend on whether the governance form is competitive or cooperative. In the following, we assess how and to what extent these drivers appear in the two governance forms.

The market maker function of PTAs. PTAs have to achieve the goals set by political decision-makers. One instrument available to them is the awarding procedure.

- <u>Relevance to the competitive governance form</u>. To attract bidders, PTAs must maintain a level playing field and keep the market attractive. This requires elimination of the incumbent's potential for discrimination or its competitive advantage, e.g., that stemming from public ownership. Ensuring the market remains attractive has become one of the most important and most challenging tasks for PTAs in Germany. The key lever here is risk allocation. Since the global financial crisis of 2008, external funding of new rolling stock has become very difficult for many TOCs except the incumbent DB Regio. This created a strong competitive imbalance. To keep the market attractive for DB Regio's competitors, PTAs have developed instruments such as state credit guarantees or set up their own rolling stock companies. These instruments are complex, especially from a legal point of view. Transaction costs can therefore grow high. Similarly, many of DB Regio's competitors are barely able to carry the risk to revenues over a contract period of up to 22 years. Often, only the incumbent has the relevant data on revenues. PTAs thus usually offer gross cost contracts. Moreover, TOCs do not have to bear all the risks of production costs such as fluctuations in energy prices (which are bound to a public price index) or train path prices (paid directly by the PTA).

- Relevance to the cooperative governance form. There is no relevance since there is no competition for the market. Swiss TOCs can cope more easily with different risks. They profit from possible monopoly prices, long-term transport licences, very short contract periods, and public ownership.
- Summary. One of the major drivers of transaction costs in Germany's competitive governance form is PTAs' efforts to sustain the bidding market. This primarily involves the transfer of different kinds of risks from TOCs to PTAs.

Formalisation of long-term contractual relationships. Unambiguous descriptions of the desired service, subsequent conversion into a contract, and clear allocation of responsibilities are challenging tasks in the current context, as they substantially increase transaction costs. This is particularly true if the level of complexity is high and the contract duration long. Ambiguous contract specification can lead to complaints and legal consequences. Comprehensive formalisation, however, also has a restraining effect on transaction costs through the clarification of rights, obligations, tasks, and responsibilities. During the contract period, a degree of calm descends, and TOCs can concentrate on providing transport services. Formalisation can partly be replaced by mutual trust among stakeholders.

- Relevance to the competitive governance form. Because of long contract durations and the necessity of equal treatment of all (potential) bidders, formalisation is indispensable. The specification and awarding criteria must be watertight. All relevant details have to be known at the bidding stage. Any potential for misinterpretation must be eliminated. Costly conflict resolution in court has been prevalent in Germany's RPT. During the contract period, specifications can only be modified within narrow limits. Contracts are therefore quite static. Significant events during the contract period (e.g., financial problems or substantial adjustments to service levels) provoke high transaction costs.

- Relevance to the cooperative governance form. Regular negotiations, business continuity, informal collaboration, and trusting partnerships in Switzerland's RPT are a substitute for comprehensive formalisation. Stakeholders solve conflicts through dialogue. This has a restraining effect on transaction costs. However, informal collaboration may also increase transaction costs. In Switzerland's RPT, there is a strong focus on quality improvements, innovation, and secondary political objectives (such as fostering regional development). This has two reasons. First, stakeholders implicitly face a soft budget constraint (footnote 9). Second, the state often simultaneously takes on the role of owner of a TOC and the PTA. Combined with an informal collaboration culture, this results in a high degree of activism, with regular modifications to service specifications and frequent launches of projects to advance RPT. A focus on innovation and high levels of flexibility, while undoubtedly promoting the further development of RPT, reduces planning reliability, increases the need for coordination, and this comes with substantial transaction costs. As a result, stakeholders start to establish more formalised relationships, e.g., by using target agreement contracts with a minimal duration of four years. In addition, formalisation is growing due to tighter public budgets, the diverging goals of different PTAs, and higher degrees of complexity on different levels (such as the technological and legal environments).
- Summary. The effect of formalisation on transaction costs is ambiguous. Both high levels (competitive governance form) and low levels (cooperative governance form) of formalisation lead to high transaction costs, but due to different causes. It is likely that transaction costs related to formalisation grow with contract duration and complexity, regardless of the governance form.

Fragmentation of the market and the culture of collaboration. To provide customer-friendly system services, cooperation between stakeholders is usually necessary. If the market is highly fragmented into numerous self-interested TOCs, cooperation may become difficult, e.g., due to free-riding (Gross, 2009).

- Relevance to the competitive governance form. Competition can result in a dynamic market structure with a high number of TOCs mainly focusing on their own costs, risks, and profits. In Germany, responsibilities for system services have therefore been partly reallocated to PTAs (e.g., superordinate marketing and timetable integration).[14] As a precondition, PTAs must acquire the appropriate knowhow. With regard to cooperation culture, interviewees in Germany mentioned the legalistic behaviour of the incumbent at the outset of the competitive area, e.g., deliberately delaying tendering procedures by initiating legal cases. Such behaviour requires even stronger formalisation and safeguarding (see above). Today, however, legal certainty is high, and legalistic behaviour and conflict resolution using legal instruments have decreased. Among stakeholders, a constructive and pragmatic culture of cooperation has emerged in the sense of "thin trust" (Hensher et al., 2007: 413), with a restraining effect on transaction costs.

- Relevance to the cooperative governance form. In Switzerland, the number of TOCs is static. The most important stakeholder with regard to system services is the SBB. Cooperation is based on "thick trust" (Hensher et al., 2007: 413) and business continuity, which limits transaction costs. Naturally, however, TOCs primarily follow their own business interests. Therefore, PTAs still exert a substantial influence over system services. The high degree of system integration is often a consequence of the corresponding regulation. E.g., nationwide fare integration—one journey, one ticket—may be organised by the TOC association. The law, however, states that only TOCs participating in nationwide fare integration are compensated—a genuinely effective incentive with low transaction costs.
- Summary. Germany incurred high institutional transition costs after the reform. Responsibility for several system services had to be reallocated, often to PTAs. Moreover, due to the fragmentation of the market and the competitive environment, transaction costs to establish the necessary level of cooperation are higher than in the cooperative governance form. This relates to the level of trust among stakeholders. Cooperation in the competitive governance form is based on thin trust, while we observe (partially) thick trust in the cooperative governance form. Nevertheless, we do not find substantial differences in terms of transaction costs related to the provision of system services; what differs is the allocation of responsibilities.

Incentive schemes and asymmetries of information. By using incentive schemes, PTAs aim to foster goals such as cost efficiency, passenger numbers, and service quality. Incentive

[14] Another reason for reallocating system service responsibilities is the potential for discrimination that relates to some such services.

schemes have to be specified, negotiated, implemented, and managed, leading to transaction costs for both PTAs and TOCs.

- Relevance to the competitive governance form. Incentive schemes are widely used by German PTAs. Most often the goal is to enhance quality, since TOCs might be tempted to reduce costs to the detriment of service quality.
- Relevance to the cooperative governance form. PTA-TOC relationships in Switzerland are typical principal-agent relationships with distinctive asymmetries of information. To legitimise the high amount of public funds devoted to RPT, PTAs use competition surrogates such as benchmarking, target agreement contracts, and open-book procedures, instruments that are often complex and require appropriate knowhow. Moreover, PTAs verify TOCs' offers very carefully, leading to costly question and answer games and micromanagement of negotiations and contracts. Besides the transaction costs related to these activities, they potentially place burdens on mutual trust. In Switzerland, another feature may serve as a competition surrogate. Swiss voters' high levels of support for public transport, as revealed in many popular votes and often related to substantial public funding, pushes TOCs to deliver satisfactory results.
- Summary. One of the major drivers of transaction costs in Switzerland's RPT is PTAs using competition surrogates to overcome information asymmetries and legitimise the public funds devoted to RPT. By comparison, the transaction costs of incentive schemes applied in Germany to stipulate quality and ridership are substantially lower.

Changing the operator imposes transaction costs and additional risks. A new TOC must acquire knowledge about the service and organise staff, rolling stock etc., in a timely fashion. Intense cooperation between the PTA, the incumbent, and the new TOC is necessary. Information asymmetries may become an issue if staff, rolling stock, or maintenance facilities are transferred from the incumbent to the new TOC. The incumbents occasionally incur residual costs, while potential start-up difficulties by the new TOC affect customers negatively.

- Relevance to the competitive governance form: Operator changes are an intrinsic feature of competition for the market. Although in Germany's major market such changes usually work smoothly, there are still exceptions. In the case of Dieselnetz Südwest, the new TOC *Netinera* was not able to provide the contracted service level for half a year after severe start-up difficulties.[15] In addition, because of the risk of losing a contract, TOCs' limit

[15] Such negative examples are often put forward as an argument against competitive tendering, e.g., after the British private TOC *National Express* recently won the tender for S-Bahn Nurnberg.

investment and innovation to what pays off by the end of the contract period. This may have detrimental effects on innovation and advancing RPT.

- Relevance to the cooperative governance form. There is no relevance since there is no competition for the market.
- Summary. Operator changes are a direct consequence of competition for the market, and may lead, even when working smoothly, to significant transaction costs.

In summary, we find substantial differences regarding where and why transaction costs accrue in the two governance forms we are comparing. The most important drivers in both cases relate to how PTAs strive to achieve optimal outcomes in terms of cost efficiency, quantity, and quality of RPT services. In the competitive governance form, PTAs use competitive tendering to obtain the best value for money. They must therefore continuously ensure that the bidding market works sufficiently well. In the cooperative governance form, conversely, PTAs use various competition surrogates to overcome information asymmetries and level bargaining power with TOCs.

5.3 Quantitative comparisons

As the availability of precise and comprehensive data on transaction costs in RPT governance is limited, we can only present rough estimates and indicators to establish the plausibility of our qualitative results. Moreover, we cannot disaggregate the estimates into the four dimensions outlined in section 5.1. The first comparison below is potentially more comprehensive, while the second only includes costs related to awarding contracts.

Proportion of transaction costs in total costs

One way to assess TOCs' transaction costs quantitatively is to consider the proportion of overhead costs in total costs (Merkert, 2010). Figure 2 shows the SBB's average RPT cost structures in all Switzerland and for small and medium railway networks in the RMV area. The proportion of overhead costs is identical. For more complex RPT networks, we lack exact data for direct comparisons. The proportion of overhead costs, however, is higher regardless of the governance form, which we attribute to the higher level of complexity.

We also look at the proportion of PTA staff assigned to contracting RPT by the RMV (Germany) and by the ZVV (Switzerland). Both are considered highly professional and experienced PTAs with similar tasks. We find that the two PTAs assign around the same proportion (roughly 5 percent) of total staff to tasks directly related to contracting.

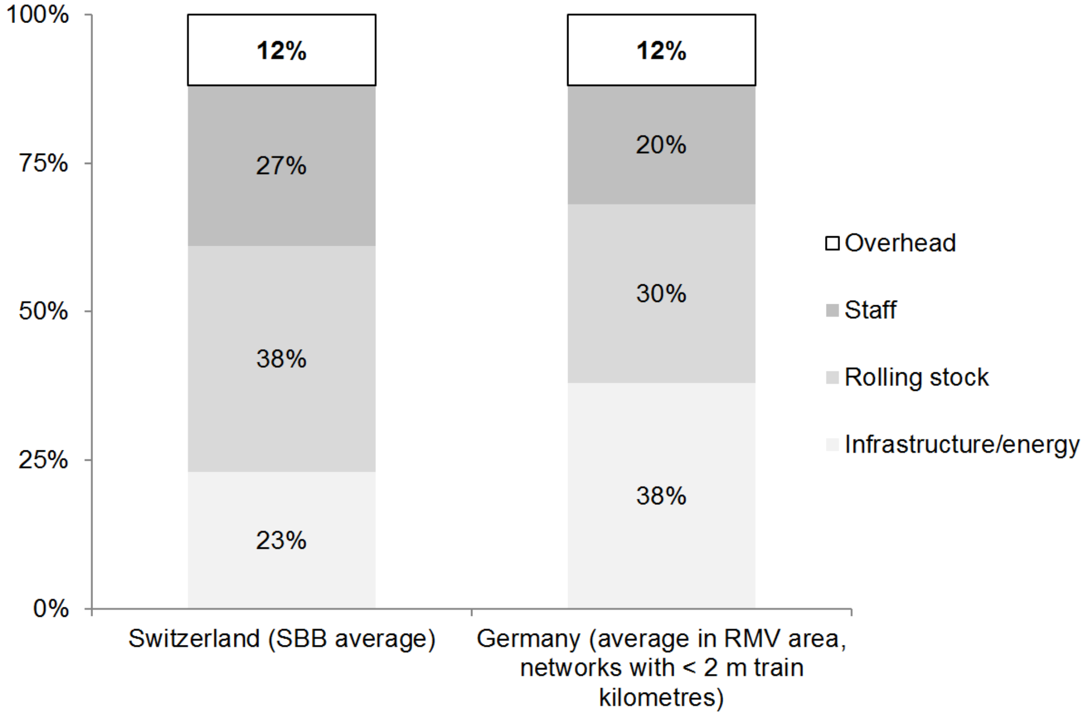

Figure 2 TOC cost structures: proportion of total costs per train-kilometre. Source: interviews.

In summary, we do not find obvious differences in PTAs' and TOCs' transaction costs between the case studies considered.

Transaction costs in awarding procedures

Table 3 compares the transaction costs of awarding procedures between the competitive tendering of S-Bahn Rhein-Main and the direct awarding of S-Bahn Zurich. The costs of both PTAs and TOCs (including unsuccessful bidders in the German case) are considered. Taking into account the contract duration and the length of the RPT network, the transaction costs seem to be slightly higher in the S-Bahn Rhein-Main case. For S-Bahn Zurich, however, we are not able to identify the transaction costs of establishing and managing the nine-year target agreement contract. Moreover, experts consider the estimate of transaction costs for the S-Bahn Zurich case to be at the lower boundary. Overall, transaction costs may therefore not differ substantially between these two particular awarding procedures. In either example, transaction costs are almost negligible compared to the total costs and compensation payments.

Even if the transaction costs of awarding procedures do not differ substantially in amount, they are incurred at different stages: German PTAs are closely engaged in the preparation stage, e.g., compiling tender documents. Swiss PTAs devote a higher proportion of their time to examining and negotiating TOCs' offers. TOCs in Germany work hard to write a potentially successful bid, whereas Swiss TOCs have to negotiate and revise their initial offers.

Table 3 Comparison of transactions costs in awarding procedures (both in 2014). Exchange rate CHF/EUR=1.2 (at the end of 2014; Swiss National Bank, 2016). Source: interviews.

	S-Bahn Rhein-Main (RMV)	S-Bahn Zurich (ZVV)
Total transaction costs (one contract period)	EUR 5–7 million	CHF 0.6 million (EUR 0.5 million)
Annual transaction costs	EUR 0.27–0.38 million	CHF 0.3 million (EUR 0.25 million)
Annual transaction costs per million train-kilometres	EUR 15,000–21,000	CHF 16,000 (EUR 13,333)
Miscellaneous	▪ Three contracts; nine lines; about 15 million train-kilometres per year ▪ Contract duration: 16–22 years ▪ Without contract management and management of incentive schemes	▪ 14 lines; about 19 million train-kilometres per year ▪ Contract duration: 2 years ▪ Without transaction costs for target agreement contract ▪ Contract management included in awarding procedure (high regularity)

6. Discussion and concluding remarks

There seems to be a consensus that competition for the market results in higher transaction costs than direct awarding. However, the awarding procedure is neither the only nor the key driver of total transaction costs in RPT governance, especially when competition is narrowed to the production of RPT services, as in the German model. An analysis that goes beyond the contract awarding procedures and includes other transaction costs reveals a more comprehensive picture. In our comparison of Switzerland's cooperative governance form and Germany's competitive governance form, we do not find evidence that the level of transaction costs of one governance form is substantially higher than the other. What differs, however, is where and why transaction costs occur. This directly relates to institutions, actors, practices, and levels of trust among stakeholders that are inherent in the respective governance form. With regard to the drivers of transaction costs, the main difference between the two governance forms is the way PTAs make sure that TOCs produce satisfactory RPT services in terms of cost efficiency and quality. In the competitive governance form, PTAs channel their efforts into ensure a functioning bidding market. In the cooperative governance form, PTAs devote many resources to introducing multiple competition surrogates in order to overcome information asymmetries and legitimise public funds devoted to RPT.

Our results contribute to the ongoing debate about optimal governance forms for RPT. In particular, our insights permit an additional and different perspective when it comes to choosing between a competitive and a cooperative governance form. With a special focus on Switzerland's rail RPT, we argue that transaction costs per se do not provide a convincing argument against an increased use of competitive instruments. In fact, the German governance form could serve as the role model for Switzerland if competition for the market is introduced there one day as well. Service levels, service quality, and cost efficiency have risen without excessively increasing transaction costs. However, it would entail a radical change in culture for Swiss stakeholders, and responsibilities and risks would need to be clearly defined and reallocated to ensure a functioning bidding market and the provision of system services. PTAs must acquire the appropriate knowhow. Before the major railway reform in the mid-1990s, Switzerland's TOCs were tightly bound to the public administration. Since the reform, they have bundled most of the relevant knowhow and often subtracted it from PTAs. Ultimately, Switzerland would have to accept that state-owned incumbents risk being driven out of the market if they lose a contract. This risk can be quite high because of the small size of Switzerland's RPT market. Consequently, institutional reforms would take a long time and incur high one-time institutional transition costs.

When assessing the introduction of a competitive governance form in Switzerland, we also must keep in mind the state of Germany's RPT before its railway reform (section 3.1). Initial improvements in cost efficiency largely consisted of windfall gains. In Switzerland's RPT, PTAs also introduced different instruments to enhance cost efficiency, such as the ordering principle and the compensation principle. Moreover, democratic pressure may serve as an effective competition surrogate. Therefore, cost efficiency gains like those observed in Germany are not a realistic scenario for Switzerland. Few studies have attempted to estimate cost inefficiency in Switzerland's rail RPT. Arguably the most comprehensive study by Farsi et al. (2005) reveals average inefficiency estimates of approximately 6–8 percent of total yearly company costs (with maximum values of 31–38 percent). However, the panel the authors use only covers the period from 1985 to 1997, i.e., before the major railway reform. More recent estimates from Ecoplan (2008) using cross-sectional data show a much higher degree of inefficiency on the RPT line level. Both studies are limited by their benchmarking character, only showing relative efficiency compared to the best practice within the sample (Farsi et al., 2005).

Germany has more than 20 years' experience of competition in RPT. Today, PTAs tender out entire suburban railway networks. Switzerland can profit from these experiences, even if the current principal-agent relationship without competition for the market is maintained. Fewer but larger and more professional PTAs take responsibility for functionally defined market areas (decoupled from administrative borders), thereby realising economies of scale in awarding procedures, dissipating duplications, and ensuring that PTAs and TOCs meet on an equal footing. Additionally, giving TOCs and PTAs clearly defined responsibilities and longer contract periods with binding goals for TOCs will strengthen their commitment, planning reliability, and incentives to achieve cost efficiency.

In return, Germany could draw some lessons from the Swiss RPT case, provided there is compatibility with higher-level law.[16] More flexible contract elements ease (joint) ex-post governance, as well as advances with RPT and also foster mutual trust. One such contract element is the rollover of contracts if PTAs are satisfied with a TOC's performance.

Mainly owing to the methodology we use and the limited number of cases we consider, our study has some limitations. First, when compared to other cooperative governance forms, Switzerland's RPT governance has various peculiarities (e.g., short contract durations and a high level of mutual trust), possibly limiting the scope for generalisation. However, we believe that, although the drivers of transaction costs outlined in section 5.2 are partially specific to Switzerland's RPT governance, they apply quite generally. Second, we concentrate on two countries only. A larger sample using other, distinctive case studies from other countries would allow further insights. In particular, a cooperative governance form with long contract periods would be a logical extension to our study. Third, as our quantitative results are based on rough estimates, we cannot rule out inaccuracies.

The limitations of our study could be a starting point for future research. One promising future research project is a more detailed quantitative analysis of the drivers of transaction costs, e.g., using Merkert's (2010) top-down approach. Besides, the question of how innovation and customer orientation (and related transaction costs) depend on the governance form has been raised only recently (Schaaffkamp, 2014). To date, this question remains vastly unanswered, despite being highly relevant for the advancement of RPT.

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[16] As non-EU member, Switzerland is not bound to EU legislation and thus has a greater degree of freedom in shaping the legal foundation of RPT.

References

Achenbach, H., Fry, V. L., & Norgall, T. (2013). Die Vergabe der S-Bahn Rhein-Main. *Der Nahverkehr 1-2*, 42–49.

Aderle, G. (2013). 20 Jahre Bahnreform in Deutschland: Von Bundesbahn und Reichsbahn zur Deutschen Bahn AG. *Verkehrsmanager*, 6–9.

Alexandersson, G., & Hultén, S. (2006). Competitive tenders in passenger railway services: Looking into the theory and practice of different approaches in Europe. *European Transport / Trasporti Europei*, *33*, 6–28.

Arrow, K. J. (1969). The Organization of Economic Activity: Issues Pertinent to the Choice of Market versus Nonmarket Allocation. *The Analysis and Evaluation of Public Expenditure: The PPBS System*, *1*, 59–73.

Augustin, K., & Walter, M. (2010). Operator changes through competitive tendering: Empirical evidence from German local bus transport. *Research in Transportation Economics*, *29*, 36–44.

Bajari, P., McMillan, R., & Tadelis, S. (2008). Auctions Versus Negotiations in Procurement: An Empirical Analysis. *Journal of Law, Economics, and Organization*, *25*(2), 372–399.

Baxter, P., & Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report*, *13*(4), 544–559.

Beck, A. (2011). Barriers to Entry in Rail Passenger Services: Empirical Evidence for Tendering Procedures in Germany. *European Journal of Transport and Infrastructure Research*, *11*(1), 20–41.

Beck, A., Ladewig, D., & Kühl, I. (2007). Liberalisierung im Schienenverkehr. In A. Brunetti & S. Michal (Eds.), *Strukturberichterstattung Nr. 35/1* (pp. 219–305). Staatssekretariat für Wirtschaft SECO.

Boitani, A., & Cambini, C. (2006). To bid or not to bid, this is the question: the Italian experience in competitive tendering for local bus services. *European Transport / Trasporti Europei*, *33*, 41–53.

Coase, R. H. (1937). The Nature of the Firm. *Economica*, *4*, 386–405.

Coase, R. H. (1960). The Problem of Social Cost. *American Journal of Economics and Sociology*, *3*, 1–44.

Cordella, A. (2006). Transaction costs and information systems: Does IT add up? *Journal of Information Technology*, *21*(3), 195–202.

Dalen, D. M., & Gómez-Lobo, A. (2003). Yardsticks on the road: regulatory contracts and cost efficiency in the Norwegian bus industry. *Transportation*, 30, 371–386.

Den Butter, F. A. G. (2012). *Managing transaction costs in the era of globalization*. Cheltenham: Edward Elgar Publishing.

Desmaris, C. (2014). The reform of passenger rail in Switzerland: more performance without competition? *Network Industries Quarterly*, *16*(2), 3–6.

Diekmann, A. (2007). *Empirische Sozialforschung: Grundlagen, Methoden, Anwendungen* (13th ed.). Reinbeck bei Hamburg: Rowohlt.

Dietl, H. M. (2007). Transaktionskostentheorie. In R. Köhler, H.-U. Küpper, & A. Pfingsten (Eds.), *Handwörterbuch der Betriebswirtschaft (HWB)* (6th ed., pp. 1750–1760). Stuttgart: Schäffer-Peoschel.

Ecoplan. (2008). Benchmarking: Beispiel öffentlicher Regionalverkehr. https://www.ecoplan.ch/download/ben_sb-update_de.pdf

Ecoplan. (2014). *Evaluation Bestellverfahren im Regionalen Personenverkehr*. https://www.newsd.admin.ch/newsd/message/attachments/34149.pdf

Farsi, M., Filippini, M., & Greene, W. H. (2005). Efficiency Measurement in Network Industries: Application to the Swiss Railway Companies. *Journal of Regulatory Economics*, *28*(1), 69–90.

Federal Department of the Environment, Transport, Energy and Communications (DETEC). (2016). *Vernehmlassungsvorlage über die Einführung eines Verpflichtungskredits zur Abgeltung von Leistungen im regionalen Personenverkehr (RPV) für die Jahre 2018 bis 2021*. https://www.admin.ch/ch/d/gg/pc/documents/2761/Leistungen-im-regionalen-Personenverkehr_Erl.-Bericht_de.pdf

Finger, M., & Holterman, M. (2013). *Incentive-based Governance of the Swiss Railway Sector. A study of the performance incentives created by the financing of the railways.* Florence School of Regulation.

Finger, M., Laperrouza, M., Holterman, M., Brand-Weiner, I., & Bert, N. (2012). *Governance of competition in the Swiss and European railway sector.* Florence School of Regulation.

Flick, U. (2012). *Qualitative Sozialforschung. Eine Einführung* (5th ed.). Reinbeck bei Hamburg: Rowohlt.

Garrick, D., Whitten, S. M., & Coggan, A. (2013). Understanding the evolution and performance of water markets and allocation policy: A transaction costs analysis framework. *Ecological Economics*, *88*, 195–205.

Glaser, B. G., & Strauss, A. (1967). *The discovery of grounded theory: strategies for qualitative research.* New York: Aldine.

Gross, M. (2009). Competition and Cooperation in Local Public Transport: Realistic Scenario or just a Fantasy? *Transformation in Business & Economics*, *8*(1), 86–100.

Gross, M. (2013). *Multiple Rationalitäten der kantonalen Aufgabenträgerorganisationen für den regionalen Busverkehr – Das Beispiel der Durchführung von Ausschreibungs-wettbewerben* [unpublished PhD Thesis]. Universität St. Gallen, Hochschule für Wirtschafts-, Rechts- und Sozialwissenschaften.

Hanstein, R. (2014, July). Kann es zu viel Wettbewerb geben? *Schweizer Eisenbahn Revue*, 344–347.

Hensher, D. A., & Stanley, J. (2008). Transacting under a performance-based contract: The role of negotiation and competitive tendering. *Transportation Research Part A: Policy and Practice*, *42*(9), 1143–1151.

Hensher, D. A., & Stanley, J. (2010). Contracting regimes for bus services: What have we learnt after 20 years? *Research in Transportation Economics*, *29*, 140–144.

Hensher, D. A., & Wallis, I. P. (2005). Competitive Tendering as a Contracting Mechanism for Subsidising Transport: The Bus Experience. *Journal of Transport Economics and Policy*, *39*(3), 295–321.

Hensher, D. A., Yvrande-Billon, A., Macário, R., Preston, J., White, P., Tyson, B., van de Velde, D., van Wee, B., de Aragão, J. J. G., dos Santos, E. M., & Filho, R. D. O. (2007). Delivering Value for Money to Government through Efficient and Effective Public Transit Cervice Continuity: Some Thoughts. *Transport Reviews*, *27*(4), 411–448.

Kain, P. (2006). Pitfalls in competitive tendering. In European Conference of Ministers of Transport (ECMT)*, Competitive Tendering of Rail Services* (pp. 43–125). Paris: OECD Publishing.

Kern, M. (2014). Zwischen Effizienz- und Qualitätsbestrebungen: Die Vergabe von Transportleistungen im öffentlichen Personenverkehr in der EU und der Schweiz. *Aktuelle Juristische Praxis*, *22*(12), 1806–1826.

Koller, M. (2012). *Essays on Efficiency Measurement in Network Industries* [PhD Thesis]. Eidgenössische Technische Hochschule Zürich. https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/55870/1/eth-6058-01.pdf

Kummer, S., Faller, P., Dobrovnik, M., Probst, G., Kunze, J., van de Velde, D., & van Luyn, S. (2013). *Ausschreibungswettbewerb im europäischen SPNV*. Zentrum Transportwirtschaft Logistik. https://www.bmk.gv.at/themen/mobilitaet/transport/nahverkehr/finanzierung/verkehrsdienstevertraege/ausschreibungswettbewerb.html

Laffont, J.-J., & Tirole, J. (1993). *A Theory of Incentives in Procurement and Regulation*. Cambridge, London: MIT Press.

Lalive, R., & Schmutzler, A. (2008). Exploring the Effects of Competition for Railway Markets. *International Journal of Industrial Organization*, (26), 443–458.

Lalive, R., & Schmutzler, A. (2011). *Auctions vs Negotiations in Public Procurement: Which Works Better?* (CEPR Working Paper). Department of Economics, University of Zurich.

Malone, T. W., Yates, J., & Benjamin, R. I. (1987). Electronic Markets and Electronic Hierarchies. *Communications of the ACM*, *30*(6), 484–497.

Marshall, G. R. (2013). Transaction costs, collective action and adaptation in managing complex social-ecological systems. *Ecological Economics*, *88*(April 2013), 185–194.

Mees, P. (2007). *Franchising and Performance Based Contracts: Lessons From Public Transport In Melbourne* [Paper presentation]. 10th International Conference on Competition and Ownership of Land Passenger Transport (Thredbo 10) 2007, Hamilton Island, Sydney, Australia. https://thredbo-conference-series.org/downloads/thredbo10_papers/thredbo10-themeC-Mees.pdf

Meister, U. (2012). *Mehr Markt für den Service Public*. Zürich: Verlag neue Zürcher Zeitung.

Merkert, R. (2010). Changes in transaction costs over time – The case of franchised train operating firms in Britain. *Research in Transportation Economics*, *29*, 52–59.

Merkert, R., & Hensher, D. A. (2013). Economics Regulation, trust and contractual incentives around transport contracts - Is there anything bus operators can learn from public air service contracts? *Research in Transportation Economics*, *39*, 67–78.

Mizutani, F., & Uranishi, S. (2012). Does vertical separation reduce cost? An empirical analysis of the rail industry in European and East Asian OECD Countries. *Journal of Regulatory Economics*, *43*, 31–59.

mofair, & Netzwerk Privatbahnen. (2009). *Wettbewerber-Report Eisenbahn 2008/2009*. https://mofair.de/wp-content/uploads/2019/03/01.-WettbewerberReport-Eisenbahn_2008-2009_kurz_kompr.pdf

mofair, & Netzwerk Privatbahnen. (2014). *Wettbewerber-Report Eisenbahn 2013/2014*. https://www.netzwerk-bahnen.de/assets/files/veroeffentlichungen/pdf/Wettbewerber%20Report%202013%202014(1).pdf

Monopolkommission. (2011). *Sondergutachten Bahn 2011: Wettbewerbspolitik unter Zugzwang*. https://www.monopolkommission.de/images/PDF/SG/s60_volltext.pdf

Nash, C. A., & Wolański, M. (2010). Workshop report – Benchmarking the outcome of competitive tendering. *Research in Transportation Economics*, *29*, 6–10.

North, D. C. (1992). Institutions, Transaction Cost and Economic Growth. *International Center for Economic Growth, Occasional Papers*. Panama City: International Center for Economic Growth.

Parker, D., & Hartley, K. (2003). Transaction costs, relational contracting and public private partnerships: a case study of UK defence. *Journal of Purchasing and Supply Management*, *9*(3), 97–108.

Picot, A. (1991). Ökonomische Theorien der Organisation - Ein Überblick über neuere Ansätze und deren betriebswirtschaftliches Anwendungspotential. In D. Ordelheide, B. Rudolph, & E. Büsselmann (Eds.), *Betriebswirtschaftslehre und ökonomische Theorie* (pp. 143–170). Stuttgart: C.E.Poeschel Verlag.

Pollitt, M. G., & Smith, A. S. J. (2002). The Restructuring and Privatisation of British Rail: Was it Really that Bad? *Fiscal Studies*, *23*(4), 463–502.

Preston, J. (2002). The Transaction Cost Economics of Railways. *Quarterly Journal of Transport Law, Economics and Engineering*, *7*(20/21), 6–15.

Preston, J. (2010). What's so funny about peace, love and transport integration? *Research in Transportation Economics*, *29*, 329–338.

Resch, H., & Neth, D. (2006). *ÖPNV zwischen Ausschreibungswettbewerb und Direktvergabe*.

Schaaffkamp, C. (2014). How can customer focus be strengthened in competitive tendering? *Research in Transportation Economics*, *48*, 305–314.

Schweizerische Bundesbahnen SBB. (2014). *Weiterentwicklung Regionaler Personenverkehr*. https://company.sbb.ch/de/ueber-die-sbb/verantwortung/wirtschaft-politik/positionspapiere.html

Schwilling, A., & Bunge, S. (2014). *20 Jahre Bahnreform und Deutsche Bahn AG*. Hamburg: DVV Media Group.

Shleifer, A. (1985). A Theory of Yardstick Competition. *The RAND Journal of Economics*, *16*(3), 319–327.

Strauss, A., & Corbin, J. (1998). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. Thousand Oaks: Sage.

Swiss National Bank. (2016). Foreign exchange rates – Year [Data file]. https://data.snb.ch/en/topics/ziredev#!/cube/devkua

van de Velde, D. (1999a). *Changing Trains. Railway Reform and the Role of Competition: The Experience of Six Countries*. Aldershot: Ashgate.

van de Velde, D. (1999b). Organisational forms and entrepreneurship in public transport: classifying organisational forms. *Transport Policy*, *6*, 147–157.

van de Velde, D., & Beck, A. (2010). Workshop report – Beyond competitive tendering. *Research in Transportation Economics*, *29*, 145–151.

van de Velde, D., Veeneman, W., & Schipholt, L. L. (2006). *Service design in competitive tendering in the Netherlands: shifts between authorities and operators* [Paper presentation]. European Transport Conference 2006, Strasbourg. *France*. http://web.mit.edu/11.951/oldstuff/albacete/Other_Documents/Europe%20Transport%20Conference/local_public_transport/service_design_in_1727.html

Verband Deutscher Verkehrsunternehmen VDV. (2013). *2012 Statistik*. https://www.vdv.de/vdv-statistik-2012.pdfx

Wallis, I. P., Bray, D., & Webster, H. (2010). To competitively tender or to negotiate – Weighing up the choices in a mature market. *Research in Transportation Economics*, *29*, 89–98.

Williamson, O. E. (1985). *The Economic Institutions of Capitalism. Firms, Markets, Relationale Contracting*. New York: The Free Press.

Williamson, O. E. (1996). *The Mechanisms of Governance*. New York: Oxford University Press.

Williamson, O. E. (2000). The New Institutional Economics: Taking Stock, Looking Ahead. *Journal of Economic Literature*, *38*(3), 595–613.

Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed.). Los Angeles: Sage.

Appendix to section 4 (Methodology)

Our main research question is to identify the dimensions and drivers of transaction costs in cooperative versus competitive RPT governance forms. Because of the pronounced exploratory nature of the research question, we follow a qualitative research design. In particular, we use the grounded theory approach (Glaser & Strauss, 1967; Strauss & Corbin, 1998), as have others in organizational research (Gross, 2013). Grounded theory is an iterative research process with various repeated steps, such as choosing case studies, gathering qualitative (and quantitative) data, and analysing and condensing the data. Accordingly, it relies greatly on empirical observations. Following the approach by Strauss and Corbin (1998), we explicitly include existing theoretical and empirical results as a basis for the subsequent field research.

As a first step, we conduct an extensive literature review (on New Institutional Economics, Transaction Cost Economics, and public transport governance) and talk to industry experts from PTAs, TOCs, consulting and research companies, and politics (Table A 1). These interactions follow a narrative interview approach (Flick, 2012) and provide us with an initial idea of where transaction costs in RPT governance actually matter. Interviewees also provide us with suggestions for suitable cases and contact data. Based on these initial interviews and the literature review, we develop a conceptual frame of reference in the form of a matrix. This matrix consists of dimensions of transaction costs and corresponding working hypotheses for how institutions, actors and their practices, and contexts affect transaction costs. The frame of reference is validated in additional interviews with experts from public transport consulting and research companies (Table A 1).[17] Finally, we use our frame of reference as basis for the interview guide in the case study interviews.[18]

We select our contrasting cases based on theoretical sampling, i.e., according to their theoretical relevance for our research question. The main goal is to achieve qualitative representativeness to allow analytical generalisations (Yin, 2014). We apply the principles of "minimising differences" and "maximising differences" (Glaser & Strauss, 1967: 55ff). On the one hand, our cases are sufficiently comparable to allow the extraction of common features and patterns

[17] The experts we interviewed have extensive knowledge and experience of public transport in Germany and Switzerland. Besides formal interviews, we also acquire valuable information in more informal conversations, e.g., during breaks.

[18] If new insights emerge from the case study interviews (e.g., new questions or contradictions of previous findings), we adapt the interview guide accordingly (Flick, 2012).

(minimising differences).[19] Based on these structural similarities between Germany's and Switzerland's RPT governance, knowledge transfer and mutual learning is possible (Beck et al., 2007; Finger et al., 2012; Kummer et al., 2013). On the other hand, RPT in Germany is organised competitively, with stakeholders now having vast experience of competitive tendering. In contrast, there has not yet been a competitive tender in Switzerland's rail RPT (maximising differences). In summary, the chosen study design allows us to analyse the similarities and differences in terms of transaction costs between a cooperative and a competitive RPT governance form.

Regarding cases within a single country, which therefore share the same institutional environment, we ensure that they differ in theoretically important ways. First, we select both complex suburban settings and less dense rural areas. Second, PTAs vary from rather small, less experienced PTAs with great dependence on the TOCs' knowledge to powerful PTAs with vast responsibilities (e.g., for the provision of system services). Third, depending on the governance form, cases include as many peculiarities as possible in terms of the contract awarding procedure, risk sharing, rolling stock provision, incentive contracts, contract duration, legal and operational problems, and operator changes.

For every case, we conduct interviews with the PTA and with at least one TOC. In the German cases, we also interview TOCs that were unsuccessful in a tender. We stop conducting interviews when no new insights emerge (Glaser & Strauss, 1967). Despite using an interview guide, we leave the interviewees much space to talk freely, which gives the interviews a narrative character (Flick, 2012). All interviews are recorded and transcribed. Moreover, we prepare a log of every interview with notes on important content, the interview setting, and informal statements (e.g., during breaks). In order to conclude the data-gathering process for the German cases, we interview two experts from the association of German PTAs to ensure that no major questions or topics remain unanswered (Table A 1).

In the next stage, we analyse the data (transcripts, interview logs, additional documents) using qualitative content analysis.[20] We code (conceptualise) the data as outlined in the

[19] Some examples of institutional similarities include the following. First, the political counties or regions are responsible for public transport in their areas. Second, long-distance, regional, and urban public transport are governed by separate bodies using different approaches. Third, the ordering principle and the compensation principle both apply. Fourth, the fully integrated state-owned incumbent TOC exerts a dominant role by operating the vast majority of RPT services. In addition, it operates long-distance railway services commercially in a (legal or factual) monopoly position and is responsible for many system services, such as timetabling or infrastructure management. Fifth, many small(er) state-owned TOCs operate in their regional niches.

[20] Additional documents consist of tender documents, newspaper articles, strategy papers, legal texts, and presentations.

grounded theory approach (Strauss & Corbin, 1998).[21] The procedure is as follows. First, we construct a coding scheme based on our frame of reference. Second, we code the data according to the coding scheme, but allow for new dimensions and concepts (open coding). The result is an extensive list of codes and memos.[22] Third, we group similar codes into categories and subcategories and adapt our frame of reference accordingly. Categories and subcategories then are linked to new (axial) categories in order to acquire an understanding of patterns and relations among the (sub-)categories (axial coding). This step results in a preliminary list of the dimensions and potential drivers of transaction costs for both governance forms. Finally, we condense the categories into the final dimensions and drivers of transaction costs through selective coding, whereby (sub-)categories are integrated into the key categories described in sections 5.1 (dimensions of transaction costs) and 5.2 (drivers of transaction costs).

As the last step, we validate our results. In qualitative research, this validation is of particular importance to ensure intersubjectivity since the results might be prone to subjective judgement by the researchers, their pre-knowledge of theory and the research subject, their experience, social background, and values (Diekmann, 2007). Following the communicative validation approach (Flick, 2012), a workshop with a panel of RPT experts is set up. We first present our results and then discuss them in depth. The content of the discussion is condensed in a log and incorporated into the results of the study. Table A 1 gives additional information on the interviews and the participants in the expert panel.

[21] We used ATLAS.ti, a standard software for qualitative data analysis.

[22] We use memos to outline suggested relationships, relation to theory, new questions, and potential (sub-)categories of the dimensions and drivers of transaction costs.

Table A 1 Detailed information on the interviews and the expert panel.

	Interviewee(s)	**Institution**	**Role of institution / interviewee(s)**
Expert interviews *Before case studies Duration: 1–4 hours*	Thomas Neff	SBB Deutschland GmbH	Small TOC in Germany and Switzerland / CEO
	Peter Vollmer	–	Former Swiss politician and director of the TOC association
	Ernst Boos	Thurbo	Small Swiss TOC / CEO
	Wolf-Dieter Deuschle	Public transport department, Canton of Bern	Swiss PTA / Head of department
	Markus Maibach Caspar Sträuli	Infras, Zurich	Leading Swiss consultancy for public transport governance / Senior consultants
	Christoph Schaaffkamp Lars Sturm Ingo Kühl	KCW, Berlin	Leading German consultancy for strategy and management in public transport / Senior consultants
	Felix Berschin Harald Blome	Nahverkehrsberatung Südwest, Heidelberg	German consultancy for planning and organisation of public transport / Senior consultants
Case study interviews Germany *Duration: 2–3 hours*	Kai Daubertshäuser Victor Fry	RMV	PTA S-Bahn Rhein-Main / Senior managers
	Charlotte Lutterbeck	DB Regio Hessen	Incumbent / CEO
	Andreas Ortz	Cantus GmbH	Small TOC—entrant / CEO
	Heinz-Dieter Bayer Georg Seifert Rolf Ommen	VRR	PTA S-Bahn Rhein-Ruhr / Senior managers
	Bernhard Wewers Burkhard Schulze	BAG SPNV NAH.SH	German PTA association and German PTA / CEO and senior manager
Case study interviews Switzerland *Duration: 2–3 hours*	Roland Wittwer Michel Jampen Thevarajah Thusheepan	FOT	PTA national level / Senior managers (RPT)
	Yves Gaillard Samuel Wiedemann	ZVV	PTA S-Bahn Zurich / Head and junior manager (finance)
	Oliver Biedert Bruno Schmutz	Public transport department, Canton Baselland	PTA Regio S-Bahn Basel / Senior managers
	Benno Bucher	SBB	Incumbent / Head RPT (finance and controlling)
Expert panel *After case studies Duration: 3 hours*	Benno Bucher	SBB	See above
	Christoph Schaaffkamp	KCW, Berlin	See above
	Markus Maibach	Infras, Zurich	See above
	Mischa Nugent	SBB	Incumbent / Head RPT (corporate development)
	Roland Wittwer	FOT	See above
	Samuel Wiedemann	ZVV	See above

A. 2

Is the mere threat enough? An empirical analysis of competitive tendering as a threat and cost efficiency in public bus transportation†

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Keywords: subsidised public transport, governance form, threat-based regulation, contestable market, competitive tendering, direct awarding, benchmarking, frontier analysis, cost efficiency

Classification: K23, L11, L92, L98, R48

Abstract

In the governance of public transport, competitive tendering has often demonstrated good results in ensuring cost efficiency. However, to achieve other goals, such as a high level of service quality, ridership growth, or building trusting partnerships between public transport operators and public transport authorities (PTAs), cooperative governance instruments (such as negotiations) may be more suitable. One suggestion is to use competitive tendering only occasionally but keep the threat to apply it whenever necessary, so that operators behave *as if* there were competition for the market. In addition, PTAs thereby can overcome information asymmetries and establish effective benchmarking schemes. This paper empirically assesses indirect effects of competition for the market, including competitive tendering as a threat, on cost efficiency. I use stochastic cost frontier analysis with a panel dataset of more than 850 regional bus lines in Switzerland from 2008 to 2017. Results show that inefficiency is lower for bus lines when some indirect effect of competitive tendering can be assumed. The findings indicate that a more flexible use of competitive tendering and its combination with other, cooperative governance instruments could support PTAs in pursuing cost efficiency, as well as setting additional goals in order to increase the overall welfare effect of public transport.

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1. Introduction

Recently, the debate over governance forms in public transport has been expanded with suggestions to combine competitive instruments, such as competitive tendering, with cooperative instruments, namely negotiations. Competitive tendering has matured and often led to satisfactory results, especially regarding cost efficiency.[1] In particular, it is a very effective measure when performance is lagging, as is often the case in first-round tenders. However, tendering has "not been the panacea that might have been expected" (Veeneman & Smith, 2016: 63). If production is already cost efficient, cooperative governance instruments may be more appropriate. There are several examples of countries, including Switzerland and New Zealand, that only use competitive tendering selectively but still obtain satisfactory results regarding cost efficiency. In addition, governance instruments other than competitive tendering may be preferred to achieve goals such as improvements to service quality, ridership growth, innovation, and building long-term trusting partnerships between public transport authorities (PTAs) and operators (Wegelin & von Arx, 2016). In a hybrid governance form such as this, competitive tendering has another, indirect function: it may ensure cost efficiency not only when directly applied, but also when used as source of information for benchmarking and as threat when the PTA is not satisfied with the operators' performance (Wallis et al., 2010). Consequently, Veeneman and Smith (2016) stress the need to focus research on design choices in tendering in order to improve it beyond of the cost efficiency effect alone and thereby making it a more effective instrument.

To summarise, it is essential to improve understanding of the impact of different governance instruments on the performance of public transport operators. The ultimate goal of these reflections is to reap the advantages and avoid the disadvantages of both competitive and cooperative governance instruments in order to optimise public transport from an overall welfare perspective. Different approaches are proposed in the literature. The market can be tested initially using competitive tendering to overcome information asymmetries before moving on to negotiations and benchmarking at the efficient cost level (van de Velde & Beck, 2010). Another suggestion is to use competitive tendering only as a last resort when an operator's performance is not satisfactory. Competitive tendering can therefore also serve as a threat (Alexandersson et al., 1998; Hensher & Stanley, 2008; Wallis et al., 2010). Operators, it is assumed, act as cost

[1] In this paper, efficiency means technical efficiency as opposed to other types of efficiency (Borger et al., 2002; Kumbhakar et al., 2015).

efficient, i.e., as if there were real competition for the market. Establishing such a hybrid governance form "can result in as good if not better outcomes than the automatic application of competitive tendering on all occasions" (Wallis et al., 2010: 96).

The current paper brings to the forefront the indirect effects of competitive tendering, including using competitive tendering as a threat. The first hypothesis states that the mere threat of putting a public transport service out to tender may be effective in ensuring cost efficiency, provided the threat is credible. The second hypothesis draws attention to a slightly different mechanism: operators with experience of competitive tendering may adopt cost efficient modes of production company-wide (i.e., for all the lines they operate). In addition, they reveal information about cost efficient production to PTAs as basis for benchmarking. If the indirect effects work as supposed, PTAs will not be obliged to stick to just one governance instrument to ensure cost efficiency but can combine instruments more flexibly in order to pursue additional goals like service quality and customer orientation.

To assess the indirect effects of competitive tendering on cost efficiency empirically, I apply stochastic frontier analysis (SFA) using panel data on more than 850 regional bus lines in Switzerland for 2008 to 2017. The panel nature of the data allows changes to the regulatory environment to be analysed (Dalen & Gómez-Lobo, 2003). Identification of the indirect effects of competitive tendering is based on variation in PTAs' use of competitive tendering, direct awarding, and benchmarking within their respective areas of responsibility.

The remainder of the paper is organised as follows: The next section summarises the relevant literature. Section 3 describes Switzerland's regional public bus transport. Section 4 presents the methodology and data used. Results are summarised in section 5, followed by a discussion and conclusion to the paper in section 6.

2. Literature review

The existing body of literature on contestable markets, threat-based regulation, and public transport governance provides a valuable basis for the examination of the indirect effects of competition on cost efficiency. This section provides a summary of the relevant literature.

2.1 Competitive tendering as a threat

The term "potential competition" relates to Baumol's theory of contestable markets where a credible entry threat disciplines the incumbent monopolist (Baumol, 1982: 2). Credibility is ensured by sufficiently low entry barriers. In the transportation sector, e.g., studies have been made of the contestability of airline markets (Hurdle et al., 1989) and of markets for commercial coach services (Gwilliam, 1989). The latter study extends the contestability to competition for the market and suggests that "competitive tendering is the most powerful and credible threat to incumbents" (p. 41). In non-profitable markets like the regional public bus market in Switzerland, no entry will occur naturally, no matter how low entry barriers may be. The regulator can then take over the role of a potential entrant and artificially establish a contestable market by threatening to intervene. This line of argument often appears in the antitrust context (Acutt & Elliott, 2001). E.g., Glazer and McMillan (1992) mention a case of highway construction costs falling in a US state after corresponding antitrust measures had been introduced in the neighbouring states. It is thus the fear of regulation that alters firms' behaviour, even if regulation does not occur. Threat-based regulation, however, only works if the regulator has built up a credible reputation for intervention. If the threat of regulation is effective, actual regulation does not have any (additional) effect. In contrast, if the threat is not credible, incumbents do not have to fear sanctions (Hensher et al., 2007). According to Acutt and Elliott (2001), to be credible regulators must be able to detect, e.g., abuses of market power. For this they must have adequate legal powers at their disposal, sufficient knowhow, and a reputation for intervening when necessary. Consequently, expected punishment for incumbent firms must be sufficiently large. How can this credibility be ensured in the present context?

Hensher and Stanley (2008) stress the need to continuously test the market to ensure the credibility of tendering as a fallback option and to gather information for benchmarking. For PTAs, regular market testing may also be necessary in order to keep the market alive. Albalate et al. (2010) assume that the threat to award services competitively enhances the PTA's bargaining power and thereby has a disciplining effect on costs when several bus-operating companies (BOCs) are in the market. A similar argument is put forward by Boitani and Cambini (2006), who find that cost reductions after competitive tendering are often negligible when there are no or only a few bidders besides the incumbent.

Figure 1 provides a simple conceptual model of the conditions for achieving credibility when competitive tendering is used as a threat. First, PTAs must be empowered and able to run a tendering procedure, i.e., they have the corresponding legal powers, the necessary knowhow, experience, resources, and a sufficient reputation. This includes that PTAs, in their role as market makers, must be capable of ensuring a level playing field during the bidding procedure (Wegelin & von Arx, 2016). Second, a certain number of capable bidders with sufficient resources, competences, and experience must be in the market and potentially ready to take part in a given tender. If these conditions are met, a PTA's threat to tender out a service is credible. Incumbents are exposed to the risk of losing the contract if their performance is not satisfactory.

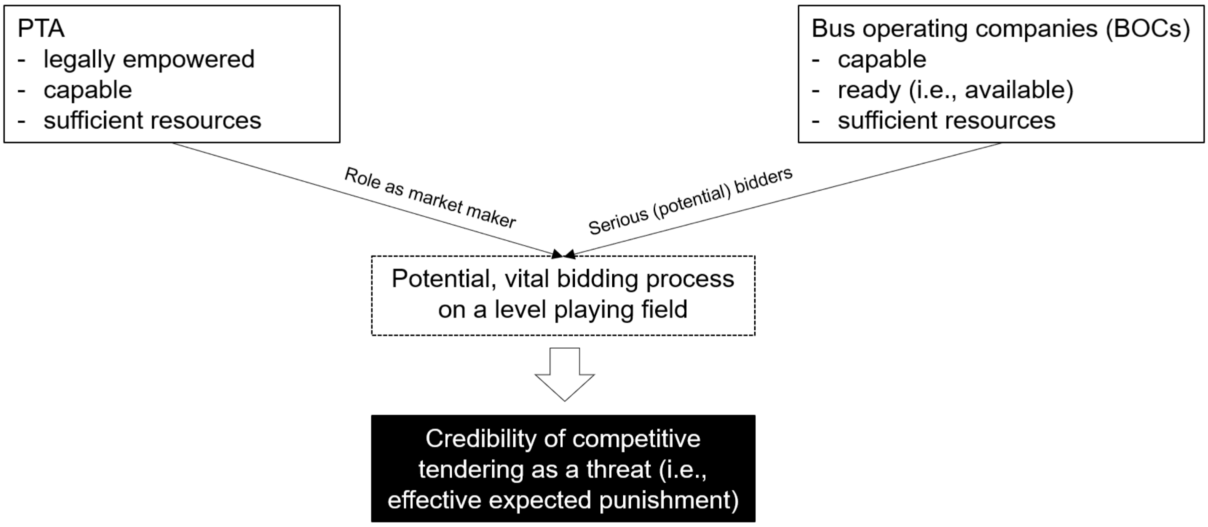

Figure 1 Simple conceptual model of the conditions for credibility of competitive tendering as a threat in public transport.

Several studies mention the possible effect of the threat of competitive tendering in public transport. Hensher and Houghton (2004) assert that the threat of competition alone, among other things, has the potential to deliver substantial cost savings. According to Alexandersson et al. (1998: 209), "[t]he threat of future tendering may encourage … operators to increase productivity in order to be competitive when tendering occurs". In addition, operators with a directly awarded contract could copy new and better production methods from operators that have been exposed to tendering. Wallis et al. (2010: 96) note that the credible threat of competition will secure at least some of the cost efficiency gains that may be achieved by using competitive tendering directly. They add that "[p]rocurement through negotiation alone, without such a threat, will rarely achieve the potential gains in efficiency and effectiveness achievable with competitive tendering". Veeneman et al. (2014: 107) conclude from interviews with public transport stakeholders that cost efficiency of untendered concessions was driven up because "the authorities did use the threat to tender". Filippini et al. (2015) cite the disciplining effect of a threat to tender as a reason why they do not find any direct effect of competitive tendering on cost efficiency.

2.2 Cost efficiency and contractual regimes in public bus transport

Numerous empirical studies have examined the variation in unit cost and cost efficiency in public bus transport, partially by treating governance instruments and contractual regimes as explanatory factors. Dalen and Gómez-Lobo (2003) show for a panel of Norwegian bus services that yardstick competition lowers cost inefficiency compared to other, less incentivised contracts. Highly incentivised contracts also lead to less deviation from minimum costs in a panel of Italian BOCs (Piacenza, 2006), as well as in French urban bus transport (Roy & Yvrande-Billon, 2007). Contracting-out local bus services has shown inefficiency-reducing effects in Japan (Sakai & Takahashi, 2013) and Sweden (Vigren, 2016). Conversely, Veeneman et al. (2014) do not find that competitive tendering had a significant effect on cost efficiency in a small panel of public bus transport contracts in the Netherlands. Unit cost or aggregate cost savings (as compared to increased cost efficiency) after competitive tendering are reported by, e.g., Bekken et al. (2006) for Norwegian BOCs, Beck (2011) for case studies of public bus transport in Germany, and Alexandersson et al. (1998) for bus provision in Swedish counties. The latter study includes a brief examination of the effect of competitive tendering as a threat, without finding evidence. Finally, Hensher and Wallis (2005) summarise various results in a review paper, reporting mixed effects.

In the case of Switzerland's public transport, studies of cost efficiency usually do not consider governance instruments and contractual regimes (e.g., Cullmann et al., 2012; Ecoplan, 2008; Farsi et al., 2005; Farsi et al., 2006). To date, the paper by Filippini et al. (2015) is the only study that includes contractual regimes in order to explain variation in cost efficiency. They analyse a cross-section of the lines served by the biggest BOC (Postbus) only. As mentioned above, they do not find a difference in cost efficiency levels between directly awarded and competitively tendered contracts. Besides, some Swiss PTAs anecdotally report substantial unit cost reductions in first-round tenders (Amt für öffentlichen Verkehr des Kantons Bern AöV, 2011).

In summary, the review of the existing literature in sections 2.1 and 2.2 indicates that the indirect effects of competitive tendering can be suitable instruments in public transport governance. The current paper adds to this literature by empirically identifying the indirect cost efficiency effects of competitive tendering in public bus transport. To the best of the author's knowledge, only Alexandersson et al. (1998) investigate an indirect effect of competitive tendering empirically, but then only marginally. In addition, their data are on the county level and they do not examine cost efficiency but aggregate costs.

3. Switzerland's regional public bus transport system

Switzerland's regional public transport is characterized by a particularly high level of system integration, with frequent services, synchronized timetables, comprehensive fare integration, high punctuality values, and trusting partnerships between PTAs and BOCs. This good quality, however, comes at a high cost for Swiss taxpayers, who subsidise regional public transport by approximately CHF 1.9 bn per year, of which about a third (CHF 0.6 to 0.7 bn) is dedicated to bus transport.[2] Average cost recovery in Switzerland's regional public transport (including rail and buses) amounts to approximately 50 percent and has remained rather constant in recent years (Federal Office of Transport FOT, 2015; Ecoplan, 2014).[3] Funding occurs jointly and on average is shared equally by the 26 cantonal PTAs and the Federal Office of Transport (FOT). Biennial bus line contracts are usually awarded directly to incumbent BOCs. Cantonal PTAs take the lead in the awarding procedure but are supported by the FOT, which is responsible for nationwide coordination, standardisation, and benchmarking. Benchmarking is used to evaluate BOCs' bids and embraces some key performance indicators (KPI) of costs, revenues, and subsidies. In addition, several PTAs have developed sophisticated benchmarking schemes of their own that use a model-based approach similar to that in this paper. With the exception of the Zürcher Verkehrsverbund ZVV (Zurich transport authority), contracts are net-cost, i.e., BOCs collect ticketing revenues and are reimbursed the difference between expected revenues and expected costs. As extensions to the ordinary contract, target agreement contracts can be negotiated to stipulate goals for, e.g., cost efficiency, revenue, and service quality over longer time periods. PTAs were given the option of using competitive tendering in a legislative amendment in 1996. Since another reform in 2012, competitive tendering has become mandatory in certain circumstances, usually after the long-term transport licences have expired. However, PTAs still face leeway due to the law's exception clauses. To date, only some PTAs have used competitive tendering and sophisticated benchmarking. In the following, this variation among PTAs is used to identify the indirect effects of competitive tendering on cost efficiency.

4. Methodology

To assess the influence of regulation on cost efficiency, a model of technical efficiency is specified. Like many before (e.g., Dalen & Gómez-Lobo, 2003; Filippini et al., 2015; Piacenza, 2006; Sakai & Takahashi, 2013; Veeneman et al., 2014; Vigren, 2016), I estimate a cost function, assuming that BOCs minimise costs. In the Swiss case, output—essentially networks and schedules—is entirely predetermined by the PTAs, making a cost function seem appropriate (Farsi et al., 2006). As a functional form, a Cobb-Douglas cost function is chosen (Battese &

[2] Using average exchange rates for 2017 (Swiss National Bank, 2018), these numbers amount to roughly the identical value in US dollars and to 1.7 bn (0.54 to 0.63 bn for bus transport) in Euros.

[3] In bus transport, cost recovery is slightly higher than 50 percent for buses operated in agglomerations and around 35 percent for buses operated in rural areas (Ecoplan, 2014). These figures have been fairly stable over the last few years.

Coelli, 1995; Farsi et al., 2005). Sometimes, the more flexible translog function is preferred because it does not impose the Cobb-Douglas restrictions, such as an elasticity of substitution between inputs of one (Filippini et al., 2015). In this paper, the translog function serves as a robustness check for the results obtained using the Cobb-Douglas specification.

Estimation of coefficients is implemented by applying stochastic frontier analysis (SFA) as originally proposed by Aigner et al. (1977) and Jondrow et al. (1982). I formulate a stochastic cost frontier model for panel data (Battese & Coelli, 1995).[4] For each regional bus line, a cost function and a cost inefficiency function are estimated simultaneously. This procedure is common and preferred to a two-stage approach (Dalen & Gómez-Lobo, 2003). The stochastic cost frontier model is generally specified as follows:

$$C_{it} = f(Y_{it}, W_{it}, Z_{it}, G_{it}, T) \cdot \exp(v_{it} + u_{it})\,. \tag{1}$$

C_{it} are the costs for unit i in year t, Y_{it} is an output vector, W_{it} is an input price vector, Z_{it} contains a set of environmental variables, G_{it} is a vector of governance variables and T represents a linear time trend (neutral technology factor). The composite error term is $\varepsilon_{it} = v_{it} + u_{it}$. v_{it} is a random noise term reflecting random shocks, whereas u_{it} is the inefficiency term, representing the variance in costs that is not explained by the cost function (which includes the environmental variables Z_{it}) and random noise v_{it}. To separate random noise from inefficiency, distributional assumptions on the two error terms are necessary. The random noise term v_{it} is usually assumed to be $N(0, \sigma_v^2)$ and to be independent of all regressors in the cost function and the inefficiency function respectively. u_{it} is assumed to be non-negative and typically distributed half normal $N^+(0, \sigma_v^2)$ or truncated normal $N(\mu_{it}, \sigma_u^2)I(u \geq 0)$. If $u_{it} = 0$, production occurs at a cost efficient level. The mean of the inefficiency term is specified as a function of governance variables: $\mu_{it} = g(G_{it})$. These governance variables are assumed not to influence production technology directly but rather managerial behaviour. Thus, they enter the inefficiency function and not the cost function (Dalen & Gómez-Lobo, 2003). Based on Coelli et al. (1999), efficiency scores from the cost function relate to gross-efficiencies that are not yet 'corrected' by governance influences. Net-efficiency, on the other hand, considers governance variables and thus primarily represents managerial performance and skills.

[4] Besides making it possible to study changes in the regulatory environment, using panel data allows one to control for line-specific unobserved time-invariant heterogeneity that may influence cost efficiency or that may be correlated with explanatory variables (Farsi et al., 2006).

4.1 Empirical model

The Cobb-Douglas stochastic cost frontier function is implemented by equation (2). It is linearized by taking logs to reduce issues of heteroscedasticity in error terms and to ease computation. The linear homogeneity assumption of the Cobb-Douglas cost function is realised by dividing cost and price variables by the price of labour W_{it}^{L}.[5]

$$\ln\left(\frac{C_{it}}{W_{it}^{L}}\right) = \beta_0 + \beta_1 lnQ_{it} + \beta_2 ln\left(\frac{W_{it}^{K}}{W_{it}^{L}}\right) + \sum_{h=3}^{H-1} \beta_h Z_{it} + \beta_H T + v_{it} + u_{it} \,. \qquad (2)$$

C_{it} are the total operational costs of line i in year t and Q_{it} denotes output measured in seat-kilometres.[6] I use a supply-related output variable because supply is entirely determined by the PTA.[7] Demand is controlled for with the load factor. W_{it}^{L} is the price of labour per hour, calculated by dividing line-specific yearly staffing costs by productive hours.[8] W_{it}^{K} is the price of all non-labour factors—mainly capital and energy—divided by bus-kilometres, as proposed by Farsi et al. (2006) and Filippini et al. (2015). The vector of environmental variables Z_{it} captures heterogeneity and potentially different operating conditions among bus lines. Table 1 provides an overview of the environmental variables.

Table 1 Description of the environmental variables in Z_{it}.

Variable	Description / Rationale
Average travelling speed	Captures local conditions, such as congestion, number of stops, area density, and geographical or topographical characteristics.
Load factor	Passenger-kilometres per seat-kilometre. Represents demand conditions.
Supply category	Dummy variables for the supply categories “rural”, “agglomeration”, “mixed rural-agglomeration”, and “mixed rural-touristic”. Partially touristic lines receive less compensation payments.
Postbus	Dummy variable for Postbus, by far the biggest BOC in Switzerland.

β_h are the parameters to be estimated. They can be interpreted as either elasticities or semi-elasticities, depending on whether the corresponding variables are specified in logs or levels.

[5] Another important property of a microeconomic cost function is concavity in input prices. In the case of Cobb-Douglas, this property is automatically fulfilled.

[6] All cost and price variables are measured in 2017 Swiss Francs (January), using Switzerland’s official consumer price index (Federal Statistical Office FOS, 2017).

[7] For a discussion of the use of supply- or demand side-variables, see, e.g., Borger et al. (2002), Filippini et al. (2015), and Vigren (2016).

[8] Productive hours include all hours the bus is available for passengers (including turnover time).

The inefficiency term u_{it} is assumed to be truncated normally distributed $N(\mu_{it}, \sigma_u^2)I(u \geq 0)$. Mean cost inefficiency is allowed to vary depending on exogenous explanatory factors and is modelled as follows:

$$\mathrm{E}[u_{it}|\varepsilon_{it}] = \mu_{it} = \theta' G_{it} \, . \tag{3}$$

G_{it} includes governance variables, and θ is the parameter vector to be estimated. The importance of inefficiency relative to random noise and relative to the total variance of the composite error term is measured by $\lambda = \sigma_u/\sigma_v$ and $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$ respectively.

The parameters of equations (2) and (3) are estimated simultaneously with maximum likelihood. Inefficiency per bus line is determined by equation (4) using the approach by Jondrow et al. (1982), in which u_{it}-related deviations from the cost frontier are interpreted as inefficiency:

$$CE_{it} = \frac{\ln C_{frontier}}{\ln C_{it}} = \exp(-\mathrm{E}[\mu_{it}|\varepsilon_{it}]) \, . \tag{4}$$

Values closer to one are interpreted as lower inefficiency. Different specifications of the cost inefficiency function are tested, using the variables defined in Table 2.

Table 2 Description of governance variables in G_{it}.

Variable	Description / Rationale
Tendering variables	
Tendering dummy	If a line was competitively tendered.
Tendering PTA dummy	If a PTA has competitively tendered any line within its responsibility area. This variable is a proxy for the tendering experience of PTAs.
Tendering BOC dummy	If at least one line operated by a BOC has been competitively tendered. This variable represents the tendering experience of BOCs.
Benchmarking	
Benchmarking dummy	If a PTA uses sophisticated benchmarking.

The identification strategy is based on operationalisation of the indirect effects of competitive tendering. First, I assume there is a credible threat of competitive tendering if a PTA occasionally tenders out bus services. In doing so, a PTA signals its willingness and ability to use this instrument. In addition, there are 69 BOCs in regional public bus transport in Switzerland in 2017. Postbus is the dominant player. In some regions, however, other BOCs also have significant market shares and thus can be treated as serious bidders. I therefore assume that a sufficient number of capable bidders are present in the market.[9] Second, if a PTA uses sophisticated benchmarking, it can compare the cost inefficiency of bus lines in its area of responsibility to cost efficient lines that have been put out to tender, thus reducing information asymmetry. Third, BOCs that have tendering experience may become more cost efficient in the operation of non-tendered lines as well. One reason is that they adopt efficient ways of production to all services. Another potential mechanism is that PTAs benchmark the lines of a given BOC.

Unbiased estimation of the effect of governance variables on cost efficiency requires the usual exogeneity assumption to be fulfilled. If a PTA's choice of a particular governance instrument depends on unobserved factors such as its perception of the BOC's inefficiency, the coefficients would be biased (Dalen & Gómez-Lobo, 2003). The exogeneity assumption can be tested using pre-tender data (Lalive & Schmutzler, 2011). Descriptive analysis reveals that tendered lines differ significantly from non-tendered lines in some of the observable variables that are controlled for in the models. For instance, tendered lines are characterised by fewer passengers, fewer seat-kilometres, and higher load factors. Quite small lines are apparently put out to tender, a procedure often observed when competitive tendering is introduced to a market (Wegelin & von Arx, 2016). However, the estimated cost efficiency scores of tendered and non-tendered lines in the pre-tender stage are similar.[10] This indicates that PTAs' selection of lines to put out to tender should not be endogenous if controlled for observables. The same argument is valid for lines within and outside the area of responsibility of PTAs that use sophisticated benchmarking.

4.2 Data

The unbalanced panel of Swiss regional public bus transport lines includes data on planned costs, supply, revenues, and subsidies on a yearly basis from 2008 to 2017. Only ordinary bus lines that fall under the laws governing Swiss public transport are considered. School buses, night buses, purely tourist buses, ski-buses, dial-a-bus lines, extra trip lines, and replacement buses for temporarily closed railway lines are excluded from the sample. After eliminating observations with missing values, the dataset embraces a total of 8,993 observations. Summary statistics are given in Table 3.

[9] Experience shows that several bidders participated in all the previous competitive tenders (Amt für öffentlichen Verkehr des Kantons Bern AöV, 2011; FOT, 2017).

[10] These tests are conducted using the Kruskal-Wallis equality-of-population method (Kruskal & Wallis, 1952).

Table 3 Descriptive statistics of variables used in the estimation.

Variable	Mean	Standard deviation
Cost function variables		
Total costs C_{it} (2017 Swiss francs)	1,033,893	1,027,906
Million seat-km Q_{it}	14.82	17.05
Price of labour W_{it}^{L} (2017 Swiss francs per hour)	59.68	12.09
Price of other inputs W_{it}^{K} (2017 Swiss francs per bus-km)	3.64	1.26
Load factor (passenger-km per seat-km)	0.1	0.06
Geographical areas: rural (80%); agglomeration (6%); mixed (6%); rural mixed with tourist bus (8%)		
Average travelling speed in km/h	20.94	6.02
Contractual variables		
Total lines tendered: before 2008 (76); 2008 – 2017 (20)		
Proportion of tendered lines on total lines (tendering dummy)	0.1	0.3
Total number of PTAs with tendering experience	14 (54%)	
Proportion of lines awarded by a PTA with tendering experience[a] (tendering PTA dummy)	0.72	0.44
Total number of PTAs using sophisticated benchmarking	6 (23%)	
Proportion of lines awarded by a PTA using sophisticated benchmarking (benchmarking dummy)	0.27	0.44
Proportion of lines operated by a BOC with tendering experience (tendering BOC dummy)	0.73	0.45
Total number of BOCs with tendering experience (won or lost)	19 (27%)	

Number of observations: N = 8,993

[a] The assignment of bus lines to PTAs was somehow challenging because the data are not separated by PTAs' areas of responsibility. Numerous lines cross cantonal boarders and are ordered by more than one PTA, whereas the PTA with the highest share of the line's length usually takes the lead. I used GIS tools and official charts to assign lines to PTAs. Single errors cannot be ruled out.

Ten percent of all regional bus lines in the sample were put out to tender, and no second tendering rounds occurred before the end of the observation period. As the regional bus market is dominated by Postbus, which has experience of competitive tendering, 73 percent of all lines are operated by a BOC that took part in a competitive tender, regardless of whether it succeeded or not. 72 percent of all lines fall within the area of responsibility of a PTA with experience of competitive tendering. This is driven by the fact that one of the largest PTAs is that which uses competitive tendering most frequently. Finally, 27 percent of all lines in the sample have been awarded based on sophisticated benchmarking.

5. Results

To examine the indirect effects of competitive tendering, three models are estimated that differ regarding the specification of the inefficiency function. *Model I* uses only one dummy variable that indicates if a line was tendered out. In *model II*, another two dummy variables are added, the first considering sophisticated benchmarking applied by some PTAs, the second representing PTAs' tendering experience. *Model III* also captures BOCs' tendering experience. Estimation results are shown in Table 4.

5.1 Cost function

The estimated coefficients of the cost function show the expected signs and size. All models show economies of density of around 1.4, i.e., an increase in output measured by seat-kilometres does not lead to a proportional increase in costs, a result also found by Filippini et al. (2015) and Farsi et al. (2006) for Swiss BOCs.[11] The coefficient of the input price ratio shows the proportion of total costs attributable to input factors other than labour. Consequently, labour's share is around 65 percent, comparable to results in previous studies. A higher load factor increases costs. At first glance, this contradicts the findings of Filippini et al. (2015). However, they use passenger-kilometres as the output variable, in which case a higher load factor lowers costs because it reflects the use of smaller and less expensive vehicles, especially in rural areas where demand is often low. In contrast, I use a supply-related output variable. The load factor thus directly measures the cost-enhancing effects of high demand (e.g., cleaning costs or operational asset depreciation). Higher average travelling speeds go along with lower costs since they assume fewer stops and less intensive use of the vehicle. Bus lines in rural areas are more costly to run than those in other geographical areas. One reason for this result could be an inefficient and inflexible use of inputs due to low service frequencies. Finally, the estimation results show higher costs for Postbus. This might be explained with reference to the complexity costs of large organizations.

5.2 Inefficiency function

In all three models, governance variables affect cost inefficiency in a negative way. Direct exposure to competitive tendering significantly lowers inefficiency in *models I* and *II*. In *model III*, this effect is not statistically significant.

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[11] Economies of density are given by $\left[\frac{\partial lnC}{\partial lnQ}\right]^{-1}$ (Farsi et al., 2006). I cannot compute economies of scale because there are no data available on the length of the network served by a BOC.

Table 4 Estimation results of the stochastic cost frontier models.

	Model I		*Model II*		*Model II*	
	Coefficient	z-value	Coefficient	z-value	Coefficient	z-value
Cost function[12]						
Seat-km Q_{it}	0.717***	209.24	0.715***	212.35	0.711***	212.31
Input price ratio W_{it}^{K}/W_{it}^{L}	0.343***	32.91	0.346***	32.35	0.353***	34.00
Load factor	2.994***	47.53	3.030***	48.63	3.117***	48.64
Average travelling speed	-0.020***	-32.42	-0.019***	-32.28	-0.019***	-31.36
Postbus (dummy)	0.037***	5.89	0.034***	5.49	0.149***	3.54
Agglomeration (dummy)	-0.096***	-7.19	-0.094***	-7.08	-0.093***	-6.96
Agglomeration-rural (dummy)	-0.065***	-5.32	-0.067***	-5.47	-0.066***	-5.46
Rural-touristic (dummy)	-0.034***	-2.99	-0.037***	-3.23	-0.039***	-3.47
Constant	-10.605***	-152.44	-10.548***	-159.51	-10.472***	-162.33
Inefficiency function						
Competitive tendering (dummy)	-0.097***	-2.80	-0.077**	-2.03	-0.054	-1.23
Benchmarking (dummy)			-0.095***	-2.82	-0.110***	-2.91
PTA tendering experience (dummy)			-0.047**	-2.31	-0.014	-0.57
BOC tendering experience (dummy)					-0.135***	-2.9
σ_u	0.164***	6.85	0.196***	10.90	0.242***	13.93
σ_v	0.247***	42.18	0.241***	49.30	0.233***	55.38
λ	0.662***	22.53	0.811***	36.21	1.035***	49.85
γ	0.305		0.397		0.517	
Log-likelihood	-828.35		-818.21		-806.60	

Number of observations: N = 8,993

* Significant at 10% ** Significant at 5% *** Significant at 1%

In *model II*, PTA tendering experience has a negative effect on inefficiency. PTAs that have put regional bus lines out to tender seem to demonstrate their ability and willingness to use this instrument, thereby exerting a disciplining effect on cost inefficiency, even if there is no actual tender for a given line.[13] The sophisticated benchmarking schemes adopted by some PTAs significantly lower inefficiency in all models and indicate the potential of the yardstick

[12] To ensure convergence of the estimation, the dependent variable was normalised (mean = 1). However, where estimation was possible without normalization, results were identical.

[13] Since only a dummy variable is used, no further conclusion on the credibility and intensity of this threat can be drawn. Therefore, I test different specifications, e.g., using the proportion of tendered lines of all the lines within a PTA's area of responsibility area or requiring a minimum of two competitive tenders for a PTA to be considered as having tendering experience. The sign of the corresponding coefficient remains unchanged, whereas it is statistically significant only in the latter case.

competition kind of regulation. These benchmarking schemes profit from information revealed by bidders in actual tenders or—likewise—when competitive tendering as a threat effectively works.

In *model III*, BOCs' exposure to competitive tendering, whether as the incumbent or as the winning bidder, has a negative sign and is statistically significant. In other words, if a BOC has experienced competitive tendering, inefficiency is lower for all lines served by this BOC, including lines for which contracts are awarded directly. This effect may be attributed to BOCs' adoption of cost efficient modes of production and to benchmarking by PTAs. By including BOCs' tendering experience in the inefficiency function, the coefficients of the tendering dummy and the PTAs' tendering experience become smaller and insignificant. Hence, the individual results of the previous specifications (*models I* and *II*) do not seem totally robust.

In summary, cost efficiency-enhancing effects of indirect competition are identified, the main mechanisms being BOCs' tendering experience and the use of sophisticated benchmarking. The results regarding PTAs' tendering experience and thus the threat of competitive tendering are less conclusive. Finally, in all models the estimates of λ and γ indicate that inefficiency matters when compared to noise.

To examine the effect of PTA and BOC tendering experience and benchmarking on cost efficiency further, I estimate three additional models restricted to the subset of bus lines that have so far never been put out to tender. Table 5 shows that the above results can be confirmed.

Table 5 Inefficiency function estimates using the restricted sample without tendered bus lines.

	Model IV		*Model V*		*Model VI*	
	Coefficient	z-value	Coefficient	z-value	Coefficient	z-value
Inefficiency function						
Benchmarking (dummy)	-0.06*	-1.67	-0.087**	-2.32	-0.084**	-2.17
PTA tendering experience (dummy)	-0.047**	-2.26			-0.012	-0.47
BOC tendering experience (dummy)			-0.135***	-3.16	-0.125**	-2.5

Number of observations: N = 8,125

* Significant at 10% ** Significant at 5% *** Significant at 1%

Cost efficiency scores (net-efficiencies) per line and year are calculated in Table 6.[14] In general, cost efficiency levels are high and comparable to the findings of Filippini et al. (2015). Efficiencies are highest in *model I* (mean of 0.905), where inefficiency is only altered by direct

[14] Cost efficiency scores across all models are highly correlated with Spearman correlation coefficients above 0.95.

exposure to competitive tendering. In *models II* and *III*, the additional indirect effects of competitive tendering lead to lower mean efficiencies (0.876 for *model II* and 0.864 for *model III*). The reason for this drop in the efficiency scores is that in *model I*, the additional governance variables representing the indirect effects of competitive tendering enter the composite error term $\varepsilon_{it} = v_{it} + u_{it}$ only partially as inefficiency u_{it} (and partially as random noise v_{it}). Instead, in *models II* and *III*, these variables directly explain the variation in the inefficiency term u_{it}. Cost efficiency scores can be compared between different groups of bus lines. For instance, efficiency scores for lines where the PTA uses sophisticated benchmarking and the BOC has tendering experience are significantly higher than for lines where neither applies.[15]

Table 6 Summary of cost efficiency scores estimated for the three models.

	Model I	*Model II*	*Model III*
Mean	0.905	0.876	0.864
Median	0.908	0.882	0.875
Maximum	0.974	0.972	0.973
Minimum	0.598	0.495	0.38

5.3 Robustness

To validate the estimation results, I perform additional robustness checks. First, the influence of two particular PTAs is analysed. For this purpose, all models are estimated for subsamples *i)* without the PTA that uses competitive tendering most frequently and *ii)* without the PTA ZVV, which operates under distinct terms.[16] The results do not change in a meaningful way, and the effect of PTAs' tendering experience becomes even stronger under *i).* Second, different variable sets in the cost function (e.g., regarding the variable measuring BOCs' output) and the inefficiency function (e.g., regarding how to measure tendering experience) are tested, without changing the results. Third, to check conformity with the study by Filippini et al. (2015), a cross-sectional SFA is estimated for the 2009 subsample of all Postbus lines. The results are comparable in the sense that competitive tendering has no direct effect on cost efficiency. However, PTAs' tendering experience enters the inefficiency function with a statistically significant negative coefficient. This indicates that cost efficiency generally is higher where PTAs have partially used competitive tendering. Fourth, using data containing figures for realised costs

[15] These tests are conducted using the Kruskal-Wallis equality-of-population method (Kruskal & Wallis, 1952).

[16] The ZVV is set up somewhat differently than the other PTAs. Although it is a PTA, it also represents all BOCs within its area of responsibility vis-à-vis the FOT. It defines so-called market leader companies that are responsible for bus services in certain areas. In addition, gross-cost contracts are used.

reported by BOCs after the contract period (rather than planned costs) does not alter the estimation results except that the effect of PTAs' tendering experience becomes slightly larger and statistically significant in any model. Fifth, I specify a translog cost function instead of the more restrictive Cobb-Douglas cost function. Inefficiency function coefficients in the translog specification are slightly larger and statistically significant for all four governance variables in all models.

In summary, the robustness checks indicate that the results are quite robust to different specifications. Moreover, the reported results seem rather conservative, since two major robustness checks (specifying a translog cost function and using data on realised costs) lead to stronger and significant effects of all governance variables.

6. Discussion and Conclusion

PTAs have a vital interest in the cost efficient provision of the public transport services they procure. From an overall welfare perspective, the results of competitive tendering have been mixed. Besides, some countries have demonstrated that satisfying results can also be achieved by relying on cooperative instruments. This challenges the primacy of competition and calls for the further optimisation of governance forms. One proposed way forward is to pursue a hybrid approach. The mechanical obligation to use competitive tendering is suspended, and cooperative instruments are promoted. To ensure that operators still produce cost efficiently, competitive tendering remains an essential instrument both as a fallback option and as a vehicle to test the market for subsequent benchmarking. A credible threat of competitive tendering can be established by competent and experienced PTAs that occasionally apply this instrument, thus demonstrating both capability and willingness, and keeping the bidder market alive. As a consequence, the advantages of both competitive and cooperative governance forms can be reaped in favour of public transport in general.

The present study assesses the indirect effects of competitive tendering on cost efficiency empirically, using the example of regional public bus transport in Switzerland. The findings indicate the existence of such effects. The main mechanisms are BOCs' previous exposure to competitive tendering and sophisticated benchmarking that partially relies on competitively tendered bus lines. Politicians, regulators, and PTAs can take this result into account when (re-)designing public transport governance. In Switzerland, this means that competitive tendering could be used more broadly, at least at the outset, to test the market and allow the stakeholders to gain experience. Subsequently, other governance instruments, such as comprehensive target agreement contracts, become even more valuable because cost efficiency is ensured. In addition, nationwide benchmarking could be strengthened by adopting a sophisticated benchmarking scheme similar to that already established by certain PTAs.

If the indirect effects of competitive tendering are useful as a means to foster cost efficiency, different questions for practice and future research arise. What skills and resources do PTAs need in order to exert a credible threat of competitive tendering and to meet operators on an equal footing? How do PTAs optimally design the proposed hybrid governance form, and in particular what criteria are useful in deciding whether a service is put out to tender? How regularly should tendering be applied to keep the bidder market alive? What is the optimal design of cooperative governance instruments in a hybrid governance form? How do operators adapt their behaviour and strategy in such a regime, and what are the transaction costs? What are the overall welfare effects, including innovation, customer orientation, and ridership growth?

To conclude this article, I will point out four limitations of this study. First, despite the extensive database, only 20 bus lines were put out to tender during the panel period. This limits the ability to identify empirically the direct and indirect effects of competitive tendering. In the near future, the market will become more dynamic: by 2018, a couple of recently tendered lines will start operating. In addition, several first-round tenders in different PTA areas of responsibility are officially being planned for the near future. The present study is therefore preliminary in nature and should be repeated and extended when more data become available. Second, heteroscedasticity in the composite error term could lead to inconsistent estimates (Belotti et al., 2013; Kumbhakar et al., 2015). I reduce the severity of potential heteroscedasticity by partially logarithmising and standardising the variables used in the models. A third potential caveat is the endogeneity of regressors, especially the decision to put a bus line out to tender in the first place (but see the additional tests in section 4.1 on this potential issue). Fourth, the indirect effects of competitive tendering are measured using simple dummy variables. Even though some robustness checks are performed, the hypothesised effects might not be correctly captured using this simple method. More sophisticated estimation strategies could be developed to gain further insights into this topical issue in the governance of public transport.

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References

Acutt, M., & Elliott, C. (2001). Threat-Based Competition Policy. *European Journal of Law and Economics, 11*(3), 309–317.

Aigner, D., Lovell, C. A. K., & Schmidt, P. (1977). Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics, 6*, 21–37.

Albalate, D., Bel, G., & Calzada, J. (2010). *Urban transport governance reform in Barcelona.* (IREA Working Paper No. 2010/09). Barcelona: Research Institute of Applied Economics.

Alexandersson, G., Hultén, S., & Fölster, S. (1998). The effects of competition in Swedish local bus services. *Journal of Transport Economics and Policy, 32*(2), 203–219.

Amt für öffentlichen Verkehr des Kantons Bern AöV. (2011). *Ausschreibungen von öV-Leistungen im Kanton Bern*. https://www.bve.be.ch/bve/de/index/mobilitaet/mobilitaet_verkehr/oeffentlicher_verkehr/leistungsbestellung/ausschreibung.html

Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics, 20*(2), 325–332.

Baumol, W. J. (1982). Contestable Markets: An Uprising in the Theory of Industry Structure. *Americal Economic Review, 72*(1), 1–15.

Beck, A. (2011). Experiences with Competitive Tendering of Bus Services in Germany. *Transport Reviews, 31*(3), 313–339.

Bekken, J.-T., Longva, F., Fearnley, N., & Osland, O. (2006). Norwegian experiences with tendered bus services. *European Transport \ Trasporti Europei, 33*, 29–40.

Belotti, F., Daidone, S., Ilardi, G., & Atella, V. (2013). Stochastic frontier analysis using Stata. *The Stata Journal, 13*(4), 719–758.

Boitani, A., & Cambini, C. (2006). To bid or not to bid, this is the question: the Italian experience in competitive tendering for local bus services. *European Transport / Trasporti Europei, 33*, 41–53.

Borger, B. De, Kerstens, K., & Costa, Á. (2002). Public transit performance: what does one learn from frontier studies? *Transport Reviews, 22*(1), 1–38.

Cameron, C. A., & Trivedi, P. K. (2005). *Microeconometrics: Methods and Applications*. Cambridge: Cambridge University Press.

Coelli, T. J., Perelman, S., & Romano, E. (1999). Accounting for Environmental Influences in Stochastic Frontier Models: With Application to International Airlines. *Journal of Productivity Analysis, 11*, 251–273.

Cullmann, A., Farsi, M., & Filippini, M. (2012). Unobserved Heterogeneity and Efficiency Measurement in Public Transport. *Journal of Transport Economics and Policy, 46*(1), 51–66.

Dalen, D. M., & Gómez-Lobo, A. (2003). Yardsticks on the road: regulatory contracts and cost efficiency in the Norwegian bus industry. *Transportation, 30*, 371–386.

Ecoplan. (2008). Benchmarking: Beispiel öffentlicher Regionalverkehr. https://www.ecoplan.ch/download/ben_sb-update_de.pdf

Ecoplan. (2014). *Evaluation Bestellverfahren im Regionalen Personenverkehr*. https://www.newsd.admin.ch/newsd/message/attachments/34149.pdf

Farsi, M., Filippini, M., & Greene, W. (2005). Efficiency Measurement in Network Industries: Application to the Swiss Railway Companies. *Journal of Regulatory Economics, 28*(1), 69–90.

Farsi, M., Filippini, M., & Kuenzle, M. (2006). Cost Efficiency in Regional Bus Companies An Application of Alternative Stochastic Frontier Models. *Journal of Transport Economics and Policy, 40*(1), 95–118.

Federal Office of Transport FOT. (2015). *Reform für den Regionalen Personenverkehr der Schweiz.* https://www.newsd.admin.ch/newsd/message/attachments/44520.pdf

Federal Office of Transport FOT. (2017). Ausschreibungsdatenbank Buslinien [Data file]. Unpublished.

Federal Statistical Office FOS. (2017). Consumere Prices [Data file]. https://www.bfs.admin.ch/bfs/en/home/statistics/prices/consumer-price-index.html

Filippini, M., Koller, M., & Masiero, G. (2015). Competitive tendering versus performance-based negotiation in Swiss public transport. *Transportation Research Part A: Policy and Practice, 82*, 158–168.

Glazer, A., & McMillan, H. (1992). Pricing by the firm under regulatory threat. The *Quarterly Journal of Economics, 107*(3), 1089–1099.

Gwilliam, K. M. (1989). Setting the Market Free. Deregulation of the Bus Industry. Journal of *Transport Economics and Policy, 23*(1), 29–43.

Hensher, D. A., & Houghton, E. (2004). *Performance Based Contracts* (Working Paper ITS-04-03). Institute of Transport Studies, University of Sydney and Monash University.

Hensher, D. A., & Stanley, J. (2008). Transacting under a performance-based contract: The role of negotiation and competitive tendering. *Transportation Research Part A: Policy and Practice, 42*(9), 1143–1151.

Hensher, D. A., & Wallis, I. P. (2005). Competitive Tendering as a Contracting Mechanism for Subsidising Transport: The Bus Experience. *Journal of Transport Economics and Policy, 39*(3), 295–321.

Hensher, D. A., Yvrande-Billon, A., Macário, R., Preston, J., White, P., Tyson, B., van de Velde, D., van Wee, B., de Aragão, J. J. G., dos Santos, E. M., & Filho, R. D. O. (2007). Delivering Value for Money to Government through Efficient and Effective Public Transit Cervice Continuity: Some Thoughts. *Transport Reviews*, *27*(4), 411–448.

Hurdle, G. J., Johnson, R. L., Joskow, A. S., Werden, G. J., & Williams, M. A. (1989). Concentration, Potential Entry, and Performance in the Airline Industry. *The Journal of Industrial Economics, 38*(2), 119–139.

Jondrow, J., Knox Lovell, C. A., Materov, I. S., & Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics, 19*(2–3), 233–238.

Kruskal, W. H., & Wallis, W. A. (1952). Use of Ranks in One-Criterion Variance Analysis. *Journal of the American Statistical Association, 47*(260), 583–621.

Kumbhakar, S. C., Wang, H., & Horncastle A. P. (2015). *A practitioner's guide to stochastic frontier analysis using Stata*. New York: Cambridge University Press.

Lalive, R., & Schmutzler, A. (2011). *Auctions vs Negotiations in Public Procurement: Which Works Better?* (CEPR Working Paper). Department of Economics, University of Zurich.

Piacenza, M. (2006). Regulatory Contracts and Cost Efficiency: Stochastic Frontier Evidence from the Italian Local Public Transport. *Journal of Productivity Analysis, 25*(3), 257–277.

Roy, W., & Yvrande-Billon, A. (2007). Ownership, Contractual Practices and Technical Efficiency: The Case of Urban Public Transport in France. *Journal of Transport Economics and Policy, 41*(2), 257–282.

Sakai, H., & Takahashi, Y. (2013). Ten years after bus deregulation in Japan: An analysis of institutional changes and cost efficiency. *Research in Transportation Economics, 39*(1), 215–225.

Swiss National Bank. (2018). Foreign exchange rates – Year [Data file]. https://data.snb.ch/en/topics/ziredev#!/cube/devkua

van de Velde, D., & Beck, A. (2010). Workshop report – Beyond competitive tendering. *Research in Transportation Economics, 29*, 145–151.

Veeneman, W., & Smith, A. (2016). Workshop report: Effective institutional design, regulatory frameworks and contract strategies. *Research in Transportation Economics, 59*, 60–64.

Veeneman, W., Wilschut, J., Urlings, T., Blank, J., & van de Velde, D. (2014). Efficient frontier analysis of Dutch public transport tendering: A first analysis. *Research in Transportation Economics, 48*, 101–108.

Vigren, A. (2016). Cost efficiency in Swedish public transport. *Research in Transportation Economics, 59*, 123–132.

Wallis, I. P., Bray, D., & Webster, H. (2010). To competitively tender or to negotiate – Weighing up the choices in a mature market. *Research in Transportation Economics, 29*, 89–98.

Wegelin, P., & von Arx, W. (2016). The impact of alternative governance forms of regional public rail transport on transaction costs. Case evidence from Germany and Switzerland. *Research in Transportation Economics, 59*, 133–14

A.3

The importance of high performing team members in complex team work: results from quasi-experiments in professional team sports[†]

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Keywords: peer effects, team production, performance, difference-in-difference, high performing team member, reciprocal interdependence
JEL classification: J24, L23, L83

Abstract

This paper empirically assesses peer effects of high performing team members in reciprocally interdependent team production. Using data from the National Basketball Association (NBA), we identify peer effects by exploiting unforeseen in-game injury dropouts of high performing players. Results indicate that without a high performing player, other team members maintain efficiency but increase risk, decrease output, and divide tasks more evenly among each other. These effects mainly depend on whether a high performing player has a team-oriented or a self-oriented role in the team. Additionally, we observe that relatively skilled players try to step in for the absent high performing player. We discuss potential mechanisms for these results.

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1. Introduction

In modern economies, many tasks are executed by appointed teams of workers. Thereby, output is a function of the combined effort of multiple team members (Alchian & Demsetz, 1972; Mas & Moretti, 2009). Some arbitrary examples include police intervention, R&D, software development, surgery, political campaigns, construction, engineering, product development, consulting, and professional sport teams. One salient characteristic of team production is peer effects, i.e., genuine effects on worker's productivity which result from the circumstance of having coworkers (Ichniowski and Preston 2014). Peer effects are essential for many organizations because "mechanisms in which individuals influence the productivity of others … directly influence the performance of organizations" (Oettl 2012, 1138).

In this context, high performing team members (HPTM) are of particular interest. Besides a large individual contribution to team performance, they may disproportionally affect other team member's performance. Peer effects of HPTMs can be positive or negative. Positive peer effects occur when team members are either positively motivated by the HPTM's performance or the HPTM directly facilitates task fulfillment. In this regard, Oettl (2012) emphasizes the social dimension of "helpfulness" to other team members. In the case of negative peer effects, a serious effort by a HPTM can induce other team members to take a free ride or a particularly dominant HPTM reduces opportunities of the other team members to perform well.

The literature on peer effects often proposes behavioral explanations, such as mutual monitoring and peer pressure, social norms, shame, reputation, or guilt (Cornelissen, Dustmann, & Schönberg, 2017; Georganas, Tonin, & Vlassopoulos, 2015; Kandel & Lazear, 1992; Mas & Moretti, 2009; Simester & Knez, 2000). These concepts strongly rely on the degree of observability (and measurability) of individual performance by peers or a principal (Ichniowski & Preston, 2014; Mas & Moretti, 2009). For instance, if it is difficult to attribute team performance to individual team members, motivation loss and social loafing can appear in the presence of a HPTM, which corresponds to a negative peer effect (Irwin & Feltz, 2016; Osborn, Irwin, Skogsberg, & Feltz, 2012). Apart from behavioral concepts, Gould and Winter (2009) propose an approach that fully relies on rational considerations, i.e., income maximization, when only overall team performance is observable. A team member's effort then lowers (increases) the effort of peers if they are substitutes (complements) in the production process.

Although it is widely acknowledged that peer effects matter empirically (Ichniowski & Preston, 2014), evidence for the effect direction is mixed. In an extensive systematic review of studies on peer effects, Herbst and Mas (2015) report that 60 percent of the reviewed papers find significant, mostly positive peer effects, while 40 percent find no evidence. Most of these studies examine how relatively more productive individuals affect their peers' performance. As an exception, Azoulay, Graff Zivin, and Wang (2010), Oettl (2012), and Waldinger (2012) examine peer effects in coauthoring scientific papers, explicitly focusing on the subgroup of HPTMs. Another feature that many of the studies reviewed by Herbst and Mas (2015) have in common is no or only little interdependence between peers.[1] Similarly, research on peer effects in team production predominantly examines settings with little direct interaction among team members or with a strictly sequential workflow. A prominent example is the study of Mas and Moretti (2009) that finds strong positive productivity effects of relatively more productive supermarket cashiers on other cashiers in the same shift when they are within visual sight of each other but not in direct interaction.

To date, much less attention has been paid to peer effects in complex team production processes prevailing in many real world workplaces. Complex team production can be characterized by close, constant and often ad-hoc interaction among multiple team members. Thompson (1967, 55) calls this situation "reciprocal interdependence", where "the outputs of each become inputs for the others". In the present empirical study, we want to fill this gap by examining peer effects when production is reciprocally interdependent. Our focus is exclusively on peer effects of HPTMs.

We address two prominent difficulties of empirical studies on team production. First, there is often a lack of observability and missing or incomplete performance data (Arcidiacono, Kinsler, & Price, 2017; Kuehn, 2017; Mas & Moretti, 2009). Second, it is challenging to find a setting which allows for causally isolating peer effects. To overcome these caveats, we use professional sports as real world laboratory. In professional sports, team production is common and diverse, including many reciprocally interdependent activities. Moreover, sports data allow precise identification and measurement of individual and team performance. Further, data are abundant and individual characteristics are detailed and complete (Arcidiacono et al., 2017; Kahn, 2000; Kendall, 2003; Neugart & Richiardi, 2013). Finally, sport environments provide the opportunity to exploit quasi-experiments (Kahn, 2000; Neugart & Richiardi, 2013).

Specifically, we use data from professional basketball, namely, the National Basketball Association (NBA). The structures of professional basketball are often considered a suitable comparison to many corporations (Chen & Garg, 2018; Day, Gordon, & Fink, 2012; Keidel, 1985). Production in basketball is reciprocally interdependent and entails complex interactions among team members with different skill levels (Chen & Garg, 2018; Ishak & Ballard, 2012).

[1] Some examples include packing envelopes (Falk & Ichino, 2006) or solving anagrams and playing computer games (Flynn & Amanatullah, 2012).

Basketball players take on different roles (e.g., positions on the court) but at the same time are required to possess a great deal of generalist skills (Keidel, 1985). Finally, similar to many other tasks in modern economies, there is substantial competition and time pressure during a basketball game.

Previous empirical research on peer effects in sports examined sequential interactions among team members, e.g., in athletics relay teams (Depken & Haglund, 2011), in swimming relay teams (Neugart & Richiardi, 2013), and in baseball (Gould & Winter, 2009). We are not aware of empirical studies on peer effects in reciprocally interdependent production, such as basketball. Existing papers that partially relate to peer effects in basketball do not explicitly address HPTMs and have different foci. For example, they measure the individual contribution of basketball players to overall team success depending on the peers with whom they are playing (Arcidiacono et al., 2017; Kendall, 2003; Kuehn, 2017).

To answer our research question, we exploit unexpected, sudden injury dropouts of high performing players during NBA games. Adaptation to the changed environment of team members who are still in action (hereinafter remaining team members) must occur immediately and is based on preexisting resources.[2] We operationalize team members' performance with four measures: Field Goal Percentage (FG %), a measure for efficiency; expected individual FG %, a measure for risk taking; the number of Field Goal Attempts (FGA), a measure for output; and the distribution of FGA among team members. Applying a difference-in-difference (DiD) approach, we show that the injury dropout of a HPTM does not change efficiency, but remaining team members take more risk, reduce output, and divide tasks more evenly among themselves. The effects are stronger the larger the 'skill gap' between the HPTM and the team's average. In addition, the effects are driven by HPTMs with a team-oriented rather than a self-oriented role in the team. Eventually, remaining HPTM (other than the HPTM who drops out) react differently to the dropout than the average team member. They seem to step in (or take advantage of the window of opportunity) by increasing output, however, without managing to fully compensate. Based on our results, we argue that with constant and reciprocal interaction, the facilitating nature of (some) HPTMs potentially is the most important mechanism for the observed peer effects.

We extend previous findings on peer effects from less interdependent and sequential settings by showing empirically that peer effects of HPTMs exist in reciprocally interdependent

[2] Some previous studies examine the effect of injury dropouts of important team members in team sports (e.g., Chen and Garg 2018; Stuart 2017). However, remaining team members have time to adapt at least until the subsequent game, e.g., by reassessing the organization of human capital or practicing.

team production in real world contexts. Our results reveal how team members react immediately to an unexpected absence of a HPTM, i.e., without having much opportunity to adapt. Moreover, our study allows a disaggregated view on peer effects by considering the roles of HPTMs and the moderating influence of the relative skill levels in a team.

The remainder of this paper is organized as follows: Section 2 describes the empirical setting, the identification strategy, and the data, while section 3 introduces the model and the variables. We present our results in section 4, together with comments on robustness. Section 5 discusses the results in a broader context and concludes the paper.

2. Empirical setting and data

We obtain play-by-play data of N=6,423,839 events in 15,707 NBA games, spanning 13 regular seasons from 2004/05 to 2016/17, from ESPN, the major US based sports television channel. Play-by-play data include a complete sequence of outcome-relevant events during a game, such as FGA, Free Throws (FT), rebounds, turnovers, fouls, ejections, substitutions, and timeouts. We exclusively focus on FGA taken by a given team during a game (n=1,286,179 FGA). We complement play-by-play data with important player characteristics (e.g., performance, position, injuries) and team characteristics (e.g., team performance) from https://www.prosp ortstransactions.com (injuries), http://insider.espn.com/nba:hollinger/statistics (player statistics), http://stats.nba.com (player and team statistics), and https://www.espn.com (injuries).

To identify high performing players in the NBA, we use Player Efficiency Rating (PER), a common measure of a player's per-minute productivity that combines a variety of individual performance statistics over one season. PER exhibits the highest correlation with salaries among various performance measures and, thus, reflects market outcomes (Arcidiacono et al., 2017). We identify players as high performing if their PER belongs in the top 20 percent percentile of the distribution of PER of all NBA players in a given season. Using the top 20 percent percentile is justified by the "80-20" rule echoed by practitioners, stating that 80 percent of the work in a firm is accomplished by 20 percent of the workers (Chen & Garg, 2018). We include only high performing players who play at least half of all games in the given season and on average are at least half the total game time on the court during these games. This method avoids considering high performing players with small influence on other team members due to little presence.

To isolate the contribution of high performing players on their peers, we exploit unforeseeable injury dropouts during a game. Injuries create a quasi-experiment "[s]ince injuries are unpredictable and beyond anyone's control …" (Chen and Garg 2018, 1250). Injuries usually happen as a result of an unforeseen event and are independent of coaching decisions or individual performance. We then examine performance of peers of the high performing player before and after the injury dropout. The context (the game) thus stays the same, which is important since in the heat of the moment, there is only limited opportunity to adapt to the changed situation. For instance, the roster for that particular game is fixed and no new plays or routines can be developed and practiced. Figure 1 visualizes our identification strategy.

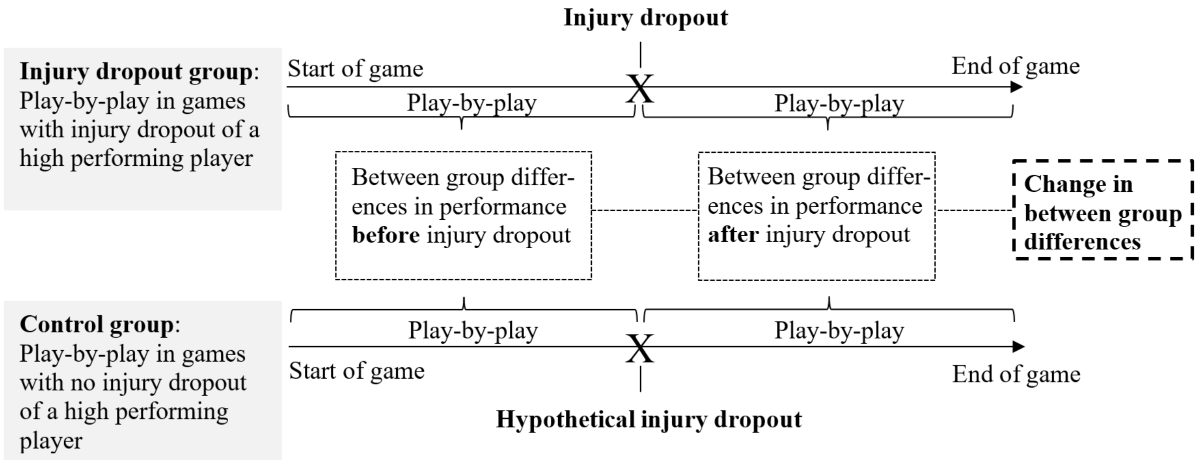

Figure 1 Identification strategy.

While the "NBA Injury Report" includes players who miss entire games because of an injury, there is no data for in-game injuries. To identify relevant games, we follow a multi-stage procedure. First, we pick all games with missing high performing players due to an injury. Second, we look at the last game before the high performing player appears on the injury report. We assume an in-game injury if a high performing player definitively leaves this game before the end of the third quarter. In addition, we require that the high performing player's court time during this game is between 40 percent and 75 percent of his season average. The lower bound[3] ensures a certain influence of the player on the other team members, while the upper bound considers the early leave due to the injury. Third, we draw a random sample of 100 identified games and cross-check with ESPN media reports if there is an injury dropout of the high performing player, which we can confirm in all 100 cases. The resulting sample consists of FGA taken by members of teams whose high performing player drops out due to an injury ("injury dropout group").

We add a control group to cope with other factors that affect performance in the course of a game and cannot (completely) be controlled for (e.g., game progression). The control group

[3] Forty percent corresponds to the bottom 25 percent percentile of the distribution of the high performing player's relative court time compared to his season average.

consists of FGA taken by members of a randomly chosen team whose high performing player (according to the criteria described before) does not drop out and is on court at least 90 percent of his season average. In the control group, we divide the before and after period using the average remaining game time after the injury dropouts in the injury dropout group.

Defining an injury dropout group and a control group allows the use of a difference-in-difference (DiD) estimation strategy (Angrist & Pischke, 2008). We compare the change in performance before and after the injury dropout between the two groups.

We exclude n=454,760 FGA in 11,621 games in the following instances: any high performing player drops out due to a different reason than injury (e.g., ejection); more than one high performing player drops out due to any reason; at least one high performing player does not play (e.g., due to rest, prior injury, or personal reasons); and the high performing player who drops out does not fulfill the requirements stated above (e.g., minimal amount of games played in a season).

Last, we restrict the period before and after the dropout to 12 minutes to ensure comparability. We thereby exclude another n=166,702 FGA. In total, our sample consists of n=10,135 FGA in 256 games (injury dropout group) and n=156,567 FGA in 3,832 games (control group).

3. Model

3.1 Variables

The dependent and independent variables are briefly summarized in Table 1 described below. Four performance measures serve as dependent variables.

The first performance measure is FG %, reflecting the ratio of a player's successful FGA to his total FGA. It is a measure for a player's shooting efficiency that mainly depends on a player's skills and the zone of the basketball court the FGA is taken from (Figure 2). Because we control for how well a player on average scores from a given zone of the court, we do not expect an effect of the high performing player's injury dropout on the efficiency of other players.

The second performance measure is expected individual FG %, a measure for risk taking. It reflects how promising a player's shooting position is in terms of a successful FGA. We calculate this variable using the career FG % of a player making an attempt from a particular zone of the basketball court (Figure 2). We hypothesize that high performing players create opportunities for other team members, bringing them into promising positions for FGA and thereby increase their expected individual FG % (which corresponds to lower risk). We expect risk to increase after an injury dropout of a high performing player.

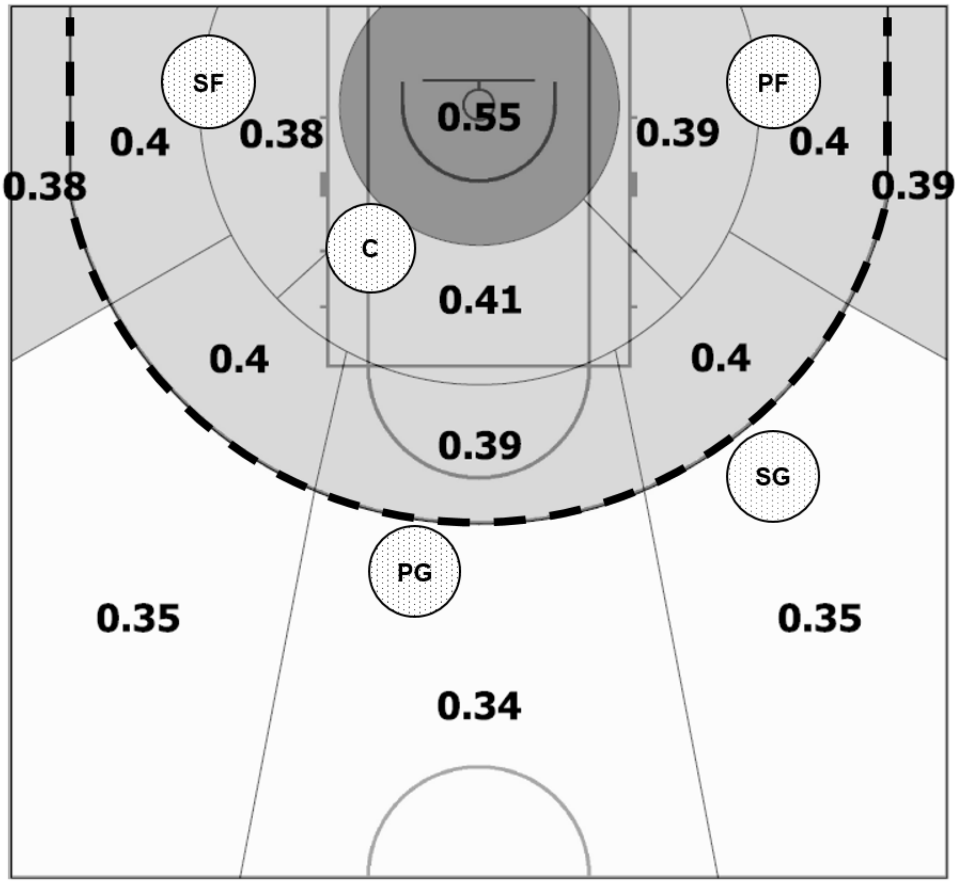

Figure 2 Shot chart with average Field Goal Percentages (FG %). Based on NBA seasons 2004/2005 to 2016/2017 and players with at least one whole season in the NBA. The dashed line represents the separation between three point FGA (outside) and two point FGA (inside). Circles with letters correspond to the usual positions (for an exemplary lineup): PG=Point Guard; SG=Shooting Guard; SF=Small Forward; PF=Power Forward; C=Center.

The third performance measure is the number of FGA normalized to 48 minutes, a measure for output. High performing players may speed up the pace of the game, thereby increasing output of all team members. Hence, we expect output to decline after an injury dropout of a high performing player.

The fourth performance measure is task allocation, measuring team routines. We use shot balance as a proxy for this variable.[4] Shot balance measures the distribution of FGA among players while taking into account the players' court times. A higher shot balance indicates a more equal distribution of FGA among players. Since high performing players supposedly are dominant players, we expect a more equal distribution of FGA after the injury dropout.

[4] Shot balance is calculated as follows: $SB_i = \sum_i s_i \log s_i / \sum_i m_i \log m_i$ with s_i and m_i representing the proportions of shots and minutes of player i in a given game (Chen & Garg, 2018).

Table 1 Variable overview.

Variable	**Description**	**Reason for inclusion as dependent variable**
Dependent variables		
FG %	Field Goal Percentage (FG %) measures the successful percentage of shot attempts from the field. It depends on the ability of a player, the court zone where a shot is taken, and the competing team's defense behavior. A higher FG % indicates higher efficiency.	FG % is a measure for efficiency.
EXPECTED INDIVIDUAL FG %	Expected Field Goal Percentage for every FGA in %. Every FGA has a success probability that depends on zone specific (Figure 2) career FG % of the player taking the FGA. A higher average FG % corresponds to a lower risk.	Average FG % is a proxy for how risky FGA are on average. It is also used as control variable.
FGA 48	Number of Field Goal Attempts (FGA) normalized to 48 minutes. A higher FGA per 48 minutes indicates a higher pace in output production and thus more output.	FGA 48 is a measure for output and is also used as control variable.
SHOT BALANCE	Shot balance measures how (un)evenly FGA are distributed among players of a team, controlling for differences in court time of players. A low shot balance indicates a skewed distribution, i.e., a higher concentration of FGA with few(er) players.	Shot balance measures the distribution of FGA among players.
PROPORTION OF 3S	The proportion of three point FGA on total FGA in %.	This measure is a (rough) indicator for risk taking.
Independent variables		
PER OF HIGH PERFORMING PLAYER'S TEAM	Average PER of all players on court in a given game, weighted by court time of the players.	PER is used as a measure for a team's average offense ability.
RELATIVE PER DIFFERENCE	PER of a team relative to PER of the competing team.	This variable is an indicator of relative (offense) abilities of the competing team.
PER DIFFERENCE OF HIGH PERFORMING PLAYER	PER of the high performing player in comparison with the average PER of his team	The effect of the high performing player depends on his (relative) offense ability compared to the team's average.
CRUNCH TIME[a] *FGA*	The proportion of FGA within crunch time.	During crunch time, pressure on players is particularly high.

Variable	Description	Reason for inclusion as dependent variable
Independent variables (continued)		
HOME GAME	Dummy variable that equals one if the team of the high performing player plays in the home arena.	This variable measures the home game advantage.
DECIDED GAME FGA	The proportion of FGA when the game already is decided[b]	In a decided game, teams behave differently since there is no pressure.
SHARE OF FT	Proportion of free throws (FT) on all shot attempts (FT and FGA)	This variable is a proxy for the competing team's defense behavior (as well as "the flow" of the game).
COMPETING TEAM'S DEFENSE	The competing team's defensive rating[c] (season average). A smaller value indicates a stronger defense.	The competing team's defense ability directly affects the high performing player's team's offense performance.
POSITION	Position of the injured high performing player (guard, forward, or center).	The position is related to the role of a player in a team.
CLOSE GAME FGA	Proportion of FGA with a score difference of less than six.	Close scores can put an additional pressure on players and teams.
INITIAL SCORE	Score at the beginning of the period.	The point difference can affect behavior and tactics of a team.

[a] We define crunch time as the last five minutes in a game with a score difference of less than six points (https://nba.com).

[b] Similarly to Grund, Höcker, and Zimmermann (2013), we identify "give-ups" when the sample probability that a team wins or loses a game given the score at the end of the 3rd quarter (12 minutes before the end) is equal to one.

[c] Defensive rating is defined as the number of points a team allows per 100 possessions of the competing team within a game (https://nba.com).

Our main independent variable is the injury dropout of a high performing player. We assume heterogeneous effects. First, we expect the effects of the injury dropout to positively depend on the relative skill level of the high performing player, measured by the difference between the high performing player's PER and his team's average. In other words, the larger the skill difference, the stronger the effect. Second, we analyze the high performing player's position.[5] The difference between guards and forwards is of particular interest: High performing guards are the playmakers and usually lead their team in assists. They help others score and are characterized as "facilitators" (Arcidiacono et al., 2017). High performing forwards are dominant players who dispose of a relatively high offense effectiveness, but their role is less focused on helping others score. In this sense, their way of playing is more self-oriented than in the case of guards. Third, we expect the remaining high performing players to react differently to the injury dropout than average players because remaining high performing players have the distinct skills (and presumably high motivation) to compensate for the injured high performing player.

To complete the models, we include a series of control variables for the season and game context, characteristics of the high performing player, his team, and the competing team.

3.2 Econometric specification

The econometric model can be expressed in the usual DiD-notation (Angrist & Pischke, 2008):

$$y_{it} = \alpha + \beta_1 d + \beta_2 T + \beta_3 (d \cdot T) + \beta_4 X_{it} + \varepsilon_{it} .$$

y_{it} represents the dependent (performance) variable of game i in period t, with $t \in \{1, 2\}$ for the period before and after the injury dropout. d is a dummy variable indicating whether game i is an injury dropout game or not (injury dropout group vs. control group). T is a dummy variable which equals 0 for the period before the dropout and 1 for the period after the dropout. Hence, the interaction term $d \cdot T$ represents the variable of interest. It is equal to 1 if and only if a high performing player drops out due to an injury. X_{it} is a vector of control variables. $\beta_1, \beta_2, \beta_3, \beta_4$ are the coefficient vectors we estimate. We estimate Ordinary Least Squares

[5] In basketball, a lineup consists of five players in the following positions (Figure 2): Two guards (point guard and shooting guard), two forwards (small forward and power forward), and one center.

(OLS) with White heteroskedastic-robust standard errors to avoid inferential bias (Cameron & Trivedi, 2005).[6]

In order to estimate heterogeneous effects of the high performing player's injury dropout, we analyze subsamples (for the position of the high performing player and the effect on remaining high performing players). To capture the effect of the relative skill level of the high performing player, we extend the model to a difference-in-difference-in difference (DiDiD) form (Imbens & Wooldridge, 2007) by multiplying the interaction term $d \cdot T$ with the difference of the high performing player's PER to the team's average.

4. Results

4.1 Summary statistics

Table 2 shows the summary statistics. The average FG % is around 0.45. The number of FGA per 48 minutes is slightly above 80. The expected individual FG % is naturally very close to the average FG % but has a smaller standard deviation. Shot balance averages 0.86.

4.2 Estimation results

Results for the main DiD regression models and the heterogeneous effects are shown in Table 3 and Table 4, respectively.

Efficiency: Given the players' skills and the zone of the court a FGA is taken from, there is no significant effect of the injury dropout on FG % in all estimated models. This result can be explained by the ability of the elite NBA players to achieve a stable level of efficiency in a wide range of situations. Additionally, FG % in a given situation may not depend on effort and therefore is less prone to behavioral effects (Berri & Krautmann, 2006).

[6] In DiD-models, the common trend assumption is central for identification (Angrist & Pischke, 2008). We argue that absent any injury dropout, the two groups would, on average, have evolved the same way for the following reasons: First, the injury dropout of the high performing player is exogenous and therefore the selection of injury dropout games is random. Second, we exclude all games which could have evolved differently, e.g., due to multiple dropouts of high performing players. Third, we use a series of control variables in our models to capture potential differences between groups and periods.

Table 2 Summary statistics.

Variable	Mean	SD	Min	Max
FG %	0.457	0.12	0	0.926
FGA 48	81.87	11.88	40	136
EXPECTED INDIVIDUAL FG %	45.6	3.314	31.27	59.13
SHOT BALANCE	0.864	0.068	0.538	1.084
PROPORTION OF 3S (in %)	22.99	11.14	0.86	86.67
PERIOD 2	0.5	0.5	0	1
INJURY DROPOUT GROUP	0.063	0.242	0	1
INTERACTION TEMR (PERIOD 2 × INJURY DROPOUT GROUP)	0.031	0.174	0	1
RELATIVE PER DIFFERENCE	1.01	0.097	0.724	1.411
AVERAGE PER OF TEAM	15.61	1.153	11.1	19.37
PER OF HIGH PERFORMING PLAYER	19.58	1.81	16.67	30.89
PER DIFFERENCE OF HIGH PERFORMING PLAYER	3.973	1.992	-1.01	17.91
CRUNCH TIME ATTEMPTS	0.005	0.142	0	7
COMPETING TEAM'S BLOCKERS	0.072	0.138	0	1
DECIDED GAME ATTEMPTS	0.025	0.843	0	36
SHARE OF FT ON TOTAL ATTEMPTS	0.213	0.109	0	0.613
CENTER DROPOUT HIGH PERFORMING PLAYER	0.233	0.423	0	1
FORWARD DROPOUT HIGH PERFORMING PLAYER	0.447	0.497	0	1
GUARD DROPOUT HIGH PERFORMING PLAYER	0.319	0.466	0	1
SHARE OF CLOSE GAME ATTEMPTS	0.46	0.365	0	1
INITIAL SCORE	0.023	8.086	-32	36
HOME GAME DUMMY	0.502	0.5	0	1
ROUND	38.35	22.64	1	82

Based on n=166,702 FGA in 4,088 games.

Risk taking: The expected individual FG %, i.e., the ex-ante likelihood of a FGA taken by a given player from a particular zone of the court being successful, significantly decreases after the dropout. This means that players increasingly take FGA from zones where their expected FG % is relatively smaller. We propose three explanations for an underlying mechanism. First, players might exert less effort to get into such positions. Second, they try to compensate for the injury dropout of the high performing player by increasing risk through shifting to more three point FGA that, on average, are riskier than two point FGA (Figure 2). However, we do not find a significant increase in the proportion of three point FGA on total FGA after the injury dropout (Table A 2 in the Appendix). Third, remaining players are unable to get into promising positions for FGA, because the valuable input by the injured high performing player is missing. This last possibility finds justification in the observation that the decrease in expected individual FG % is driven by the dropout of high performing guards, who are facilitators. The risk increase after the dropout positively depends on the PER difference between the high performing guard and his team's average. In contrast, we do not observe any significant effect on risk taking of remaining high performing players (although the coefficient is basically the same as in the main model). They seem to be able and willing to maintain expected FG %.

Table 3 Regression results of DiD models.

	FG %	**FGA 48**	**Expected FG %**	**Shot balance**
PERIOD 2	-0.001	-0.168	0.511***	-0.018***
	(0.003)	(0.271)	(0.077)	(0.002)
INJURY DROPOUT GROUP	-0.006	-0.349	0.772***	-0.016***
	(0.008)	(0.719)	(0.222)	(0.005)
PERIOD 2 × INJURY DROPOUT GROUP	**0.011**	**-1.863***	**-0.96*****	**0.018*****
	(0.01)	**(0.969)**	**(0.306)**	**(0.006)**
AVERAGE PER	0.002*	0.333***	0.476***	-0.002***
	(0.001)	(0.11)	(0.033)	(0.001)
REL. PER DIFFERENCE TEAMS	0.04	2.767**	0.661*	0.01
	(0.014)	(1.945)	(0.401)	(0.008)
COMPETING TEAM'S DEFENSE	0.0005***	0.182***	-0.013***	0.001***
	(0.0002)	(0.017)	(0.005)	(0.000)
COMPETING TEAM'S BLOCKERS	-0.018*	1.04	0.169	-0.008
	(0.001)	(0.982)	(0.272)	(0.006)
CRUNCH TIME ATTEMPTS	-0.019**	0.379	0.002	0.000
	(0.008)	(0.858)	(0.237)	(0.007)
CLOSE GAME ATTEMPTS	-0.003	0.031	-0.073	-0.003*
	(0.004)	(0.35)	(0.1)	(0.002)
DECIDED GAME	0.002	0.029	-0.024	0.001
	(0.002)	(0.137)	(0.039)	(0.001)
SHARE OF FT ON TOTAL ATTEMPTS	-0.06***	-26.41***	1.203***	-0.087***
	(0.012)	(1.247)	(0.343)	(0.007)
AVERAGE ZONE FG %	0.422***			
	(0.046)			
FGA PER 48 MIN	-0.002***		0.027***	
	(0.000)		(0.003)	
INITIAL SCORE	0.000	-0.017	0.007*	0.000
	(0.000)	(0.016)	(0.004)	(0.000)
HOME GAME DUMMY	0.004	0.362	0.044	0.004***
	(0.003)	(0.254)	(0.072)	(0.001)
ROUND	0.0002***	-0.007	0.004**	0.000
	(0.000)	(0.006)	(0.002)	0.000
CONSTANT	0.356***	61.25***	36.11***	0.852***
	(0.034)	(2.828)	(0.867)	(0.017)
N	8,176	8,176	8,176	8,176
Adj. R2	0.043	0.077	0.043	0.043

Robust standard errors in parenthesis; *** p<0.01 ** p<0.05 * p<0.1

Output: We find a significant negative effect of the high performing player's dropout on output. This effect is driven by the dropout of high performing guards. Again, this is consistent with the facilitating nature of high performing guards, i.e., their team-oriented role (e.g., by passing the ball quickly to players in a promising shooting position). In addition, we observe that the bigger the difference of the high performing player's PER to the team's average, the stronger the negative effect on output. Interestingly, remaining high performing players increase their output. They seem to try to step in after the dropout. Since the effect in the main model is significantly negative, however, they do not manage to fully compensate.

Task allocation: We find shot balance is significantly higher after the injury dropout, which means that FGA are more evenly distributed among remaining players. This result indicates that, on average, no other team member fully takes over the dominant role of the injured high performing player. The effect, however, is significant only if the injured high performing player is a forward, whose rather self-oriented way of playing seems to skew task allocation. Somewhat surprisingly, the balancing effect of the injury dropout on task allocation is negatively related to the difference between the high performing player's PER and his team's average. One potential explanation is that we observe the highest average, median, and maximum PER differences for high performing guards, who do not skew task allocation.

Table 4 Heterogeneous effects – interaction terms only.

Submodels		FG %	FGA 48	Expected FG %	Shot balance
High performing centers		-0.003	-1.394	-0.298	0.017
		(0.025)	(2.27)	(0.785)	(0.016)
High performing forwards		0.02	-0.364	-0.105	0.03***
		(0.016)	(1.522)	(0.451)	(0.01)
High performing guards		0.005	-3.416**	-2.267***	0.007
		(0.016)	(1.5)	(0.474)	(0.01)
PER difference	Interaction term	0.017	0.266	-0.322	0.036***
		(0.016)	(1.418)	(0.45)	(0.01)
	Interaction term × PER difference	-0.001	-0.39**	-0.118**	-0.003**
		(0.002)	(0.197)	(0.06)	(0.001)
Remaining high performing players		0.032	2.444***	-1.06	–
		(0.024)	(0.949)	(0.718)	
High performing player by 85 percentile		0.01	-2.248**	-1.173***	0.015**
		(0.012)	(1.14)	(0.356)	(0.008)

Robust standard errors in parenthesis; *** p<0.01 ** p<0.05 * p<0.1.

4.3 Robustness analysis

In order to assess the robustness of our results, we run a series of additional tests. First, our results are robust against different approaches of correcting standard errors to avoid inferential bias, such as clustering or bootstrapping. Second, our results do not change if we apply various specifications of fixed effects for the high performing player's team and the competing team in a given season. Third, we narrow the high performing players to the top 15 percent of the PER distribution, without changing our results.[7] Fourth, our findings are robust against many different specifications and definitions of control variables. In fact, we can reproduce very similar results using a simple DiD specification without control variables (Table A 1 in the Appendix). Accordingly, results do not change if we remove all variables that are potentially prone to multicollinearity in terms of high variance inflation factors or to endogeneity. Fifth, we find no

[7] Compared to the main models, coefficients in the models for output and risk taking slightly increase, while the coefficient in the model for task allocation is slightly smaller. This is consistent with the result that the effects positively depend on the difference between the high performing player's PER and the team's average.

differences in our estimates when we exclude observations in late season games, where incentives for teams to win may be different with regard to post season (play-off) pairings or a favorable draft position (Ishak & Ballard, 2012; Walters & Williams, 2012). Finally, our results do not change if we try different requirements regarding the definition of a high performing player in terms of games played and average minutes per game. Overall, our results are robust against various alternative specifications and definitions.

5. Discussion and Conclusion

Teamwork with complex interaction patterns and skill heterogeneity is prevalent in many industries. Thereby, HPTMs make large individual contributions to team performance. In addition, they can influence performance of other team members through peer effects. Using data from professional basketball, we show that after an unexpected, sudden dropout of a HPTM, remaining team members increase risk, reduce output, and divide tasks more evenly among themselves. We observe heterogeneity in these effects: First, a higher relative skill level of the HPTM compared to the team's average amplifies the decrease in output and the increase in risk taking but attenuates the balancing effect on task allocation. Second, the effects on risk taking and output are driven by HPTMs in integrative, team-oriented roles. Task allocation becomes more even only when the absent HPTM's role is more self-oriented. Third, remaining high performing team members react differently to the sudden absence of their HPTM. They increase their output and otherwise maintain a stable performance.

These results extend previous findings on peer effects in several ways. First, we study reciprocally interdependent production in a real world context, which so far has received little attention in research on peer effects in teams. In this way, we add to the manifold results on peer effects in less interdependent or sequential team production. Next, we explicitly focus on peer effects of the subgroup of HPTMs as an important element of a team. Further, the use of multiple performance measures as well as the inclusion of heterogeneity of skills and roles allows us a differentiated and detailed view on peer effects. For instance, we extend Oettl's (2012) concept of helpfulness as a social dimension to reciprocally interdependent team production by showing that the observed peer effects are driven by facilitating HPTMs with an integrative role in the team. High individual productivity does not necessarily mean large positive peer effects and therefore, not all HPTMs contribute disproportionally to team performance (Berri & Krautmann, 2006). Eventually, our analysis of the immediate reaction to the unexpected, sudden absence of a HPTM clearly differs from other studies examining effects of absenteeism of important team members (e.g., Chen and Garg 2018; Stuart 2017) where teams have time to adapt and prepare, e.g., by practicing.

Our estimates do not allow us to explicitly disentangle the underlying mechanisms for the observed peer effects. What possibly limits the scope for behavioral explanations is that individual performance in professional basketball is constantly observed by peers, the management, and spectators. Social pressure is constantly high, presumably preventing social loafing (Osborn et al., 2012). Nonetheless, especially non-high performing team members may decrease their effort while blaming the absence of the HPTM for an inferior individual performance. Reduced effort could explain the result of lower output and higher risk because compensating for the injured HPTM requires additional (costly) effort. A more likely line of reasoning, however, relies on the facilitating nature of (some) HPTMs. Our results clearly point in that direction because the observed peer effects are mainly driven by HPTMs with a rather team-oriented role. Constant and reciprocal interaction with such team members is a direct channel for peer effects through facilitation. Non-high performing team members profit when the HPTM creates promising opportunities for them (where their marginal product is relatively higher). In other words, there is a complementary relationship between HPTMs and their non-high performing peers in that performance of one team member depends on the inputs of (high performing) peers (Oettl, 2012). In contrast, the subgroup of all HPTMs in a team, besides being complements as well, face a certain level of within-team competition among each other. Highly talented team members strive for recognition, promotion, and better contracts. They may recognize the sudden absence of a HPTM as a window of opportunity to step out of the HPTM's shadow. Their marginal products increase and they can signal their high value to the team (Gould & Winter, 2009).

To gain further insights into potential mechanisms for peer effects of HPTMs in reciprocally interdependent team production, future research could focus on effort levels and routines. In the present empirical setting, this would include measurement of distance covered, running speed, or pass patterns by using tracking data. A second promising research question in this context includes the value of HPTMs in special circumstances, such as situations of particularly high pressure or critical phases during a team task.

Our study has certain limitations. There are some important control variables we cannot consider because adequate data was not available. We are not able to fully control for tactical responses of coaches during a given game or strategic behavior in different situations (e.g., giving certain important players a rest with regard to an important subsequent game). Also, we only have limited possibilities to control for the (change in) defense behavior of the competing team. The basketball setting has certain peculiarities, potentially limiting generalizations of our results to other organizations. For instance, NBA teams consist of the world's best players with well above average salaries. In addition, basketball provides fast paced and turbulent environments with a high level of observability in terms of performance. Previous research, however, acknowledges the transferability of results from sports (and explicitly basketball) to other industries (Chen & Garg, 2018; Day et al., 2012; Keidel, 1985). Thereby, it is clear that our results mainly apply to contexts with similar characterizing levers, such as reciprocal interdependence, a constant structural working environment, measurability of performance, and different roles of team members in the production process.

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References

Alchian, A. A., and H. Demsetz. “Production, Information Costs, and Economic Organization.” *The American Economic Review*, 62(5), 1972, 777–95.

Angrist, J. D., and J.-S. Pischke. *Mostly Harmless Econometrics: An Empiricist’s Companion*. Princeton, NJ: Princeton University Press, 2008.

Arcidiacono, P., J. Kinsler, and J. Price. “Productivity Spillovers in Team Production: Evidence from Professional Basketball.” *Journal of Labor Economics*, 35(1), 2017, 191–225.

Azoulay, P., J. Graff Zivin, and J. Wang. “Superstar Extinction.” *The Quarterly Journal of Economics*, 125(2), 2010, 549–89.

Berri, D. J., and A. C. Krautmann. “Shirking on the Court: Testing for the Incentive Effects of Guaranteed Pay.” *Economic Inquiry*, 44(3), 2016, 536–46.

Cameron, C. A., and P. K. Trivedi. *Microeconometrics: Methods and Applications*. Cambridge, MA: Cambridge University Press, 2005.

Chen, J. S., and P. Garg. “Dancing with the Stars: Benefits of a Star Employee’s Temporary Absence for Organizational Performance.” *Strategic Management Journal*, 39, 2018, 1239–67.

Cornelissen, T., Ch. Dustmann, and U. Schönberg. “Peer Effects in the Workplace.” *American Economic Review*, 107(2), 2017, 425–56.

Day, D. V., S. Gordon, and C. Fink. “The Sporting Life: Exploring Organizations through the Lens of Sport.” *Academy of Management Annals*, 6(1), 2012, 397–733.

Depken, C. A., and L. E. Haglund. “Peer Effects in Team Sports: Empirical Evidence from NCAA Relay Teams.” *Journal of Sports Economics*, 12(1), 2011, 3–19.

Falk, A., and A. Ichino. “Clean Evidence on Peer Effects.” *Journal of Labor Economics*, 24(1), 2006, 39–57.

Flynn, F. J., and E. T. Amanatullah. “Psyched Up or Psyched Out? The Influence of Coactor Status on Individual Performance.” *Organization Science*, 23(2), 2012, 402–15.

Georganas, S., M. Tonin, and M. Vlassopoulos. “Peer Pressure and Productivity: The Role of Observing and Being Observed.” *Journal of Economic Behavior and Organization*, 117, 2015, 223–32.

Gould, E. D., and E. Winter. “Interactions between Workers and the Technology of Production: Evidence from Professional Baseball.” *Review of Economics and Statistics*, 91(1), 2009, 188–200.

Grund, Ch., J. Höcker, and S. Zimmermann. "Incidence and Consequences of Risk-Taking Behavior in Tournaments-Evidence from the NBA." *Economic Inquiry*, 51(2), 2013, 1489–1501.

Herbst, D., and A. Mas. "Peer Effects on Worker Output in the Laboratory Generalize to the Field." *Science*, 350(6260), 2015, 545–49.

Ichniowski, C., and A. Preston. "Do Star Performers Produce More Stars? Peer Effects and Learning in Elite Teams." NBER Working Paper 20478, Cambridge, MA: National Bureau of Economic Research, 2014.

Imbens, G., and J. M. Wooldridge. "What's New in Econometrics? Difference-in-Difference Estimation." NBER Summer Workshop, Mimeo, 2007.

Irwin, B. C., and D. L. Feltz. "Motivation Gains in Sport and Exercise Groups." In *Routledge International Handbook of Sport Psychology*, edited by R. J. Schinke, K. R. McGannon, and B. Smith, New York: Routledge, 2016.

Ishak, A. W, and D. I. Ballard. "Time to Re-Group: A Typology and Nested Phase Model for Action Teams." *Small Group Research*, 43(1). 2014, 3–29.

Kahn, L. M. "The Sports Business as a Labor Market Laboratory." *Journal of Economic Perspectives*, 14(3), 2000, 75–94.

Kandel, E., and E. P. Lazear. "Peer Pressure and Partnerships." *Journal of Political Economy*, 100(4), 1992, 801–17.

Keidel, R. W. "Football's out, Basketball's in; A New Game for Managers to Play." *The New York Times*, December 8, 1985.

Kendall, T. D. "Spillovers, Complementarities, and Sorting in Labor Markets with an Application to Professional Sports." *Southern Economic Journal*, 70(2), 2003, 389–402.

Kuehn, J. "Accounting for Complementary Skill Sets: Evaluating Individual Marginal Value To a Team in the National Basketball Association." *Economic Inquiry*, 55(3), 2017, 1556–78.

Mas, A., and E. Moretti. "Peers at Work." *American Economic Review*, 99(1), 2009, 112–45.

Neugart, M., and M. G. Richiardi. "Sequential Teamwork in Competitive Environments: Theory and Evidence from Swimming Data." *European Economic Review*, 63, 2013, 186–205.

Oettl, A. "Reconceptualizing Stars: Scientist Helpfulness and Peer Performance." *Management Science*, 58(6), 2012, 1122–40.

Osborn, K. A., B. C. Irwin, N. J. Skogsberg, and D. L. Feltz. “The Köhler Effect: Motivation Gains and Losses in Real Sports Groups.” *Sport, Exercise, and Performance Psychology*, 1(4), 2012, 242–53.

Simester, D., and M. Knez. “Firm-Wide Incentives and Mutual Monitoring at Continental Airlines.” *Journal of Labor Economics*, 19(4), 2000, 743–72.

Stuart, C. H. “Structural Disruption, Relational Experimentation, and Performance in Professional Hockey Teams: A Network Perspective on Member Change.” *Organization Science*, 28(2), 2017, 283–300.

Thompson, J. D. *Organizations in Action*. New York: McGraw Hill, 1967.

Waldinger, F. “Peer Effects in Science: Evidence from the Dismissal of Scientists in Nazi Germany.” *Review of Economic Studies*, 79(2), 2012, 838–61.

Walters, Ch., and T. Williams. “To Tank or Not to Tank: Evidence from the NBA.” Paper presented at *2012 MIT Sloan Sports Analytics Conference, MIT, Boston, MA, March 2-3,* 2012.

Appendix to section 4 (Results)

Table A 1 Regression results of simple DiD models (without controls).

	FG %	FGA 48	Expected FG %	Shot balance
PERIOD 2	-0.000	-0.401	0.532***	-0.186***
	(0.003)	(0.271)	(0.075)	(0.002)
INJURY DROPOUT GROUP	-0.015**	-0.238	0.458**	-0.013***
	(0.007)	(0.803)	(0.228)	(0.005)
PERIOD 2 × INJURY DROPOUT GROUP	**0.014**	**-2.173****	**-1.103*****	**0.018*****
	(0.01)	**(1.073)**	**(0.311)**	**(0.006)**
CONSTANT	0.463***	82.16***	45.31***	0.873***
	(0.002)	(0.139)	(0.053)	(0.001)
N	8,176	8,176	8,176	8,176
Adj. R2	0.000	0.001	0.006	0.017

Robust standard errors in parenthesis; *** p<0.01 ** p<0.05 * p<0.1

Table A 2 Regression results of DiD model for the proportion of 3s as dependent variable.

	Proportion of 3s (in %)
PERIOD 2	0.389
	(0.258)
INJURY DROPOUT GROUP	0.58
	(0.763)
PERIOD 2 × INJURY DROPOUT GROUP	**1.665**
	(1.092)
AVERAGE PER	0.55***
	(0.105)
REL. PER DIFFERENCE TEAMS	-1.732
	(1.273)
COMPETING TEAM'S DEFENSE	0.249***
	(0.016)
COMPETING TEAM'S BLOCKERS	-0.018*
	(0.001)
CRUNCH TIME ATTEMPTS	-0.326
	(0.684)
CLOSE GAME ATTEMPTS	-1.371***
	(0.337)
DECIDED GAME	0.089
	(0.201)
SHARE OF FT ON TOTAL ATTEMPTS	-2.845**
	(1.154)
FGA PER 48 MIN	-0.051**
	(0.011)
INITIAL SCORE	0.013
	(0.016)
HOME GAME DUMMY	0.201
	(0.245)
ROUND	0.017***
	(0.005)
CONSTANT	-4.327***
	(2.83)
N	8,176
Adj. R2	0.036

Note: Robust standard errors in parenthesis; *** p<0.01 ** p<0.05 * p<0.1

Curriculum vitae

Personal Details

Philipp Lukas Wegelin

Born April 26, 1983, in Bern, one brother (Lorenz Lukas Wegelin)

Married to Vera Lüthi

Daughter Franca Luisa Lüthi (born August 1, 2018)

Son Janosch Alexis Lüthi (born May 3, 2016)

Education

Jan 14 – Apr 21	Doctoral Studies in Management and Economics, University of Zurich, Chair of Services & Operations Management
Feb 06 – Oct 07	Master of Science in Economics, University of Bern (summa cum laude)
Oct 02 – Jan 06	Bachelor of Science in Economics and General Ecology, University of Bern (summa cum laude, with distinction)

Professional Experience

Oct 12 – today	Lecturer and Researcher at Lucerne University of Applied Sciences and Arts – Business, Institute for Tourism and Mobility, Competence Center for Mobility
Jun 12 – Oct 18	Examiner (Economics) at Schweizerischer Verband Technische Kader-leute
Apr 08 – Dec 11	Scientific Collaborator and Team Leader, Canton of Bern, Finance Department, General Secretariat
Oct 05 – Jul 07	Teaching Assistant (Economics and Statistics), University of Bern, Department of Economics
Jun 03 – Nov 19	Player and coach in handball on various levels

Bibliographic citation

Paper 1 The impact of alternative governance forms of regional public rail transport on transaction costs. Case evidence from Germany and Switzerland

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Paper 2 Is the mere threat enough? An empirical analysis of competitive tendering as a threat and cost efficiency in public bus transportation

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Paper 3 The importance of high performing team members in complex team work: results from quasi-experiments in professional team sports

A version of this paper has been submitted to *Economic Inquiry* and is now under revision (April 16 2021).